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RATIONAL
RECREATIONS,

In which the PRINCIPLES of

N U M B E R S

A N D

NATURAL PHILOSOPHY

Are clearly and copiously elucidated,

BY A SERIES OF

EASY, ENTERTAINING, INTERESTING
EXPERIMENTS.

Among which are

All those commonly performed with the CARDS.

By W. HOOPER, M. D.

VOL. I.

THE THIRD EDITION, CORRECTED.

L O N D O N.

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MDCCLXXXVII.



R A T I O N A L
R E C R E A T I O N S.

VOLUME THE FIRST.

CONTAINING

ARITHMETICAL AND MECHANICAL
EXPERIMENTS.



ADVERTISEMENT.

AS the design of this work is to render useful knowledge easy and entertaining, the author has selected the principal part of the experiments from the writers on recreative Philosophy of the last and present centuries ; from Baptista Porta to Ozanam and Guyot ; the last, especially, has furnished a large number of recreations that are new and pleasing, and from him also are copied several figures that the authors of the experiments they explain have only described. The writers on electricity have also contributed a considerable quantity of recreations, and such as for pleasure and surprize are inferior to none. Though this work is, in general, a compilation, some original experiments will be here found, and the whole, perhaps, will appear to be delivered with more perspicuity and concision, and digested

a.

gested in a manner more regular than has been hitherto attempted. The principles of each science are, moreover, here laid down in a few plain aphorisms, such as require no previous knowledge, and very little capacity or attention to comprehend ; so that the reader will readily discover, at the same time that he admires the phænomena, the source from whence they proceed, and learn, that far from being marvellous or incomprehensible, they are the regular and necessary effects of the laws of nature.

INTRO-

INTRODUCTION.

A MONG the various productions of the press, those that are intended for instructive entertainment seem to deserve some degree of attention, and that as well from the difficulty as the utility of the enterprize ; for though to offer useful knowledge be sufficiently easy, yet to render that knowledge engaging is oftentimes extremely difficult. Man, careless, froward, stubborn, vain, impetuous, disdains the imputation of

ignorance, and loaths the authoritative dictates of assuming superiority.

Should we not, therefore, endeavour to render useful learning, not dull, tedious, and disgusting, not rugged and perplexing, not austere and imperious, but facile, bland, delightful, alluring, captivating? that Philosophy, with his sober garb and solemn aspect, when led by the hand of the sportive nymph Imagination, decked in all the glowing ever-varying colours of the skies, may gain admittance to the parties of the gay and careless; and while his awful eye restrains the exuberance of her sallies, the beams that dart from her radiant front may play upon his countenance, and dissipate the cloud
that

that too frequently hangs over his brow.

Thus will the mind of man be pleasingly enlarged and fortified ; he will unavoidably acquire a knowledge of his own ignorance ; and by finding the fallacy of what he thought most certain, the evidence of the senses, he will learn to determine with caution on the seeming convictions of the mind, and divest himself of those prepossessions, from whence so many of the evils of life proceed.

Thus may he advance with tranquil steps through the flowery path of investigation, till arriving at some noble eminence, he beholds, with awful astonishment, the immense riches in the

boundless regions of science, and becomes animated to attain a still more lofty station ; while his heart is incessantly rapt with joys of which the grovelling herd have no conception, compared with whose ignorance, the insensibility of the blind and deaf, to the most brilliant harmony of colours, or enchanting melody of sounds, are but trifling imperfections.

Though this work is principally intended for the rising generation, yet they whom a criminal indulgence of their guardians, or a slavish submission to their own tyrannic passions, have plunged into sensuality, till incessant fruition hath produced an unconquerable loathing, or till age hath deprived them of appetite, and nought remains of
life

life but a wretched hankering after enjoyments they can never more obtain ; even they will here find an entrance to new pleasures ; they will see, with grateful admiration, that all bounteous Providence has still in store for them, joys poignant yet tranquil, perpetually increasing, yet never cloying, and that it depends on themselves still to pursue, even to the utmost verge of life, a continual round of variegated pleasures.

To each volume is prefixed, a short description of the plates contained therein, with a reference to the page where they may be found ; and to the figures in each plate, is annexed the page where such figure is fully described in the work,

At the end of each volume is added a table of contents, in which is given a regular abstract of every article ; so that the reader, after having once perused the whole, by looking over the contents, will readily remember how every recreation is to be performed.

DESCRIP-

DESCRIPTION of the PLATES.

PLATE I. p. 20.

Fig. 1. Neper's rods. There are eleven of these rods placed perpendicular and close to each other : on the first is wrote the nine digits, and on the last nine cyphers : the other nine contain a multiplication table.

Fig. 2. Example of the manner of placing the rods for multiplying and dividing.

Fig. 3. The Chinese swan pan. The perpendicular lines within the square ABCD represent bars, that divide it into seven divisions. The five horizontal lines in the upper divisions, and the seven horizontal lines in the lower divisions, on which are small black circles, represent wires ;

wires; the circles are balls moveable on those wires, and by bringing them up to the middle bar they express the sum required.

P L A T E II. p. 148.

The mystical dial. The inner circle ILMN turns round on its center O, within the other circle EFGH, so that any letter of the former may be placed against the first letter of the latter, as shall be agreed on. The letters of the one are then wrote for those of the other, as in the example under the figure.

P L A T E III. p. 152.

The musical cypher. The inner circle ILMN, on which the notes are wrote, turns round within the other circle, as in the last Plate, and the notes are here wrote for the letters, as in the example under the figure.

P L A T E IV. p. 166.

Fig. 1. The machine for visual correspondence ABCD, Fig. 1, is a circle of wood which turns on the centre G: *a*, *b*, *c*, *d*, are pins by which it turns round. Through its circumference are cut the letters of the alphabet, and between A and Z is an open space.

Fig. 2, is the pole to which the circle just mentioned is placed by its centre, near P. The board EF, at top, prevents any letter from being seen, except that directly opposite the space in its middle.

Fig. 3, is the machine for auricular correspondence. The strings to the two bells A and B, which are moveable on the cross-piece CD, are pulled one or more times, according to the letter that answers to the number of sounds.

P L A T E V. p. 178.

This plate contains the primary mechanic instruments, or mechanic powers.

Fig.

Fig. 1, 2, 3, 4, are levers of different kinds ; each of the other figures have their names annexed to them.

P L A T E VI. p. 186.

Fig. 1 and 2. A dial to go without wheels, spring, or weight. C D, Fig. 1, is the cylinder, the ends of whose axis, as they descend, point to the hours marked on the columns E F.

Fig. 2, represents the internal structure of the cylinder, which consists of five divisions, in three of which there is water, expressed by the shade.

Fig. 3 and 4. A dial to show the hour by descending an inclined plane. A B, Fig. 3, the external appearance of the dial : g, a hemisphere, on which a figure sits that points to the hour.

Fig. 4, the internal structure of the dial.

P L A T E VII. p. 194.

Fig. 1 and 2, the inscrutable lock. AB, Fig. 1, the scutcheon to the lock ; C the pinion by which it is fixed in any position.

A B C D,

ABCD, Fig. 2, the twelve wards of the key, which turn round the pipe and are fixed together by the screw E.

Fig. 3, the hand-mill to grind corn, &c. incessantly, without any animal force. ABCD a smoke-jack, that turns the rope EF, by which the mill is kept in continual motion.

P L A T E VIII. p. 196.

Fig. 1. a carriage to go without any external force. ABCD, the figure of the carriage, with the person who rides in it, and the footman who drives it.

Fig. 2, represents the machinery by which it is moved, and which is concealed in a box behind the carriage. C D are two treddles that are pushed down alternately by the man behind the carriage, and by means of the ropes C A, D A, turn the wheels H, H, which being fixed on the same axis with the great wheels I, I, turn them also.

P L A T E

P L A T E IX. p. 200.

Fig. 1. The catapulta. ABCD, the frame in which the arrows are placed; E F the spring by which they are forced out. G the post to which the rope that bends the spring is fastened.

Fig. 2. The failing chariot; A B the body of the chariot; C D the fails; E the rudder, guided by the man at the helm A.

P L A T E X. p. 206.

Fig. 1. A carriage to fail against the wind. ABCD the body of the carriage; M the mast: GEFH the fails; K the cog-wheel, that takes the teeth placed perpendicular to the sides of the fore-wheels; R the rudder by which it is guided.

Fig. 2. The uninvertible carriage. A B the body of the carriage; C the weight by which it is kept always upright; FGDE are iron circles in which it moves; P the door; O the window, and Q R the shafts.

P L A T E XI. p. 212.

Fig. 1. The case of the columnar dial. AC the capital, that contains the striking part of this dial; GH is the shaft on which are marked the hours; H the index, that by its descent shows the hour. The hand in the circle on the base B, points to the minute.

Fig. 2, shows the machinery of this dial. A is the wheel that moves the minute hand, and which is turned by the weight B, to which is fixed the hour hand H. F and G are two brass wheels fixed on the axis DE. The wheel F raises the end M of the lever MNO, and makes the other end, to which the hammer P is fixed, to strike the bell Q.

P L A T E XII. p. 222.

Fig. 1, is an air chronometer. AB is a glass tube; CD the frame in which it is placed; E a piston to let out the air; F the string by which the piston is drawn up; G the handle that confines the string of the piston.

Fig.

Fig. 2. Shows the form of the piston in the tube.

Fig. 3. A conical roller to receive the string to the index of a dial, when placed over the tube.

Fig. 2. A lamp chronometer. A is a small glass lamp, placed in the stand B, C the handle that supports the style H, and frame D E F G, which is covered with oiled paper, and on which are wrote the figures for the hours.

Fig. 5. A nocturnal dial. A and B are two wheels of the same dimension, and concentric ; C a pinion : D and E two wheels placed on the same axis ; F a lamp fixed on the edge of the wheel B ; G the weight that gives motion to the whole machine.

Fig. 6. Is a hollow cone, by which the flame of the lamp F is confined to a particular part of the wheel A.

RATIONAL RECREATIONS.

ARITHMETIC.

DEFINITIONS.

WE shall not here define the primary principles of numbers, as our readers are supposed to understand the four first rules of arithmetic, addition, subtraction, multiplication, and division ; we shall therefore begin with arithmetic powers.

1. By the powers of any number, is meant the several times that number is multiplied into itself. Thus, if 4 be multiplied into itself, the product 16 will be its second power, or square ; and if that sum be multiplied by four, the product 64 is the third power, or cube of 4, &c.

2. The root of any power is that number from whence it first sprung, or was multiplied : so the square root of 16 is 4 ; and the cube root of 27 is 3.

3. When two numbers are compared together, the first is called the antecedent, and the second the consequent ; and the proportion these numbers bear to each other is called their ratio. Thus, the ratio of 27 to 9, is that of 3 to 1.

4. When three numbers are compared together, if the difference between each of them be equal, as 2, 4, 6, or, 9, 6, 3, they are said to be in arithmetic proportion.

5. If three numbers be compared together, and they have one common ratio, that is, the same multiplier or divisor, as 3, 9, 27, or 64, 16, 4, they are in geometric proportion.

6. Whenever the consequent is double the antecedent, they are said to be in duplicate proportion ; but if the antecedent be double the consequent, they are in subduplicate proportion.

7. When

7. When any series of numbers continually increases or decreases by an equal addition or subtraction, as 2, 4, 6, 8, &c. or 18, 15, 12, 9, &c. they are said to be in arithmetic progression.

8. When a series of numbers continually increases or decreases by one common multiplier or divisor, that is, by one common ratio, as 4, 8, 16, 32, &c. or 81, 27, 9, 3, they are in geometric progression.

9. If over a series of numbers in geometric progression, there be placed another in arithmetic progression, whose common difference is 1, as thus

$$\begin{array}{ccccccc} 1, & 2, & 3, & & & & \\ & 2, & 4, & 8, & & & \\ & & 4, & 5, & \} & \text{&c.} & \\ & 16, & 32, & \} & \end{array}$$

the latter are called the indices or exponents of the former: and if the geometric series begin with 1, the other must begin with a cypher, thus,

$$\begin{array}{ccccccc} 0, & 1, & 2, & 3, & 4, & \} & \text{&c.} \\ 1, & 2, & 4, & 8, & 16, & \} & \end{array}$$

10. The several different ways that one number of quantities can be taken out of another greater number, of the same sort,

are called the combinations of the former in the latter. Thus the different ways, that three balls can be taken out of six, are the combinations of 3 in 6.

11. All the different ways the whole of any number of quantities can be taken or disposed, are called the permutations of that number; so all the different ways that six counters can be placed in a line, are the permutations of the number 6.

A P H O R I S M S.

1. If two even numbers be added together, or subtracted from each other, their sum or difference will be an even number.

2. If two uneven numbers be added or subtracted, their sum or difference will be an even number.

3. The sum or difference of an even and uneven number will be an uneven number. •

4. The product of two even numbers will be an even number; and the product of two uneven numbers will be an uneven number.

5 The

5. The product of an even and uneven number will be an even number.

6. If two different numbers be divisible by any one number, their sum and their difference will be also divisible by that number.

7. If several different numbers, divisible by three, be added or multiplied together, their sum and their product will also be divisible by 3.

8. If two numbers, divisible by 9, be added together, the sum of the figures in the amount will be either 9, or a number divisible by 9.

9. If any number be multiplied by 9, or by another number divisible by 9, the amount of the figures of the product will be either nine, or a number divisible by 9.

10. In every arithmetic progression, if double the sum of all the terms in any series be divided by the first and last term added together, the quotient will

B 3 be

be the number of all the terms in that series*.

11. In

* This and the following aphorisms, relating to progressions, may be applied to many useful purposes besides those mentioned in the course of this work. For example.

1. A man is to go a journey of 1120 miles, 40 of which he proposes to ride the first day, and to increase the number, by an equal addition, every day to the last, when he intends to ride 100 miles. How long will he be going his journey?

You have here the first term 40, the last term 100, and the sum of all the terms ~~1120~~, to find the number of terms: therefore, by aphorism 10, if the double of 1120, that is 2240, be divided by 40 added to 100, the quotient, which is 16, will be the number of terms, or days he will be going.

But, by the 11th aphorism, if the difference between the first and last term, that is 60, be divided by the number of terms less 1, which is 15, the quotient 4 will be the common difference, or number of miles he must add each day.

2. A father intends to lay up 10l. toward his daughter's portion the day she is a year old, and to increase the sum as much every year as shall make her fortune, at the end of 20 years, 1000l. What will he have to lay up the last year?

Here the first term, number of terms, and sum of the series are given, to find the last term; therefore,

11. In every such series, if the difference between the first and last term be divided by

fore by aphorism 12, if from double the sum of the series, which is 2000, you subtract the product of the first term, multiply by the number of terms, that is 200, and divide the remainder, which will be 1800, by the number of terms, the quotient 90 is the last term, or number of pounds he must lay up the last year.

3. A gentleman proposes to plant a number of trees in his grounds, for 20 years together, in regular progression, 20 the first year, and 100 the last. How many trees will he plant?

By aphorism 13, if you multiply the first and last term by the number of terms, and divide the sum of the two products, which is 2400, by 2, the quotient 1200 is the number of trees he must plant.

4. A landlord asks 5l. a year for an acre of land, which the farmer thinking too much, the landlord offers to let him a lease of it, for 21 years, at 1d. the first year, 2d. the second year, 4d. the third, and so on, doubling the sum every year. What would the farmer pay the last year? and what would be the average rent for the whole term?

Here the 20th term (which is to be considered as the last, the first term being one, which neither multiplies nor divides) will be found by the 14th aphorism to be 1,048,576 pence, or 4369l. 1s. 4d.

by the number of terms, less 1, the quotient will be the common difference between each term of that series.

12. If the product of the number of terms multiplied by the first term, be subtracted from double the sum of the series, and the remainder be divided by the number of terms, the quotient will be the last term.

13. If the first and last term be each multiplied by the number of terms, and the sum of the two products be divided by two, the quotient will be the sum of the series.

14. In every geometric progression, if any two terms be multiplied together which is the rent he will pay the last year. But, by aphorism 15, to find the sum of the series, the last term must be multiplied by the ratio 2, which will make it 2,097,152, and from that sum, the first term 1, must be deducted, when it will be 2,097,151, and that sum is to be divided by the ratio 2 less 1, that is by 1; therefore it will remain the same, and consequently be the sum of the series. Then dividing 2,097,151 by 21, the number of years, the quotient 99,864, or 416l. 2s. will be the average rent for each year.

their

their product will be equal to that term which answers to the sum of their two indices. Thus, in the series $1, 2, 3, 4, 5, 2, 4, 8, 16, 32,$ if the third and fourth terms, 8 and 16, be multiplied together, the product 128 will be the seventh term of that series. In like manner, if the fifth term be multiplied into itself, the product will be the tenth term ; and if that sum be multiplied into itself the product will be the twentieth term, &c. Therefore, to find the last, or any other term of a geometric series, it is not necessary to continue the series beyond a few of the first terms.

15. In any geometric series, if you multiply the last term by the common ratio, from the product subtract the first term, and divide the remainder by the ratio, less 1, the quotient will be the sum of that series.

16. In all combinations, if from an arithmetic decreasing series, whose first term is the number out of which the combinations

binations are to be formed, and whose common difference is 1, there be taken as many terms as there are quantities to be combined; and those terms be multiplied into each other: and if from the series, 1, 2, 3, 4, &c. there be taken the same number of terms, and they be multiplied into each other, and the first product be divided by the second, the quotient will be the number of combinations required. Therefore, if you would know how many ways four quantities can be combined in seven, multiply the first four terms of the series, 7, 6, 5, 4, &c. together, and divide the product, which will be 840, by the product of the first four terms of the series, 1, 2, 3, 4, &c. which is 24, and the quotient 35 will be the combinations of 4 in 7.

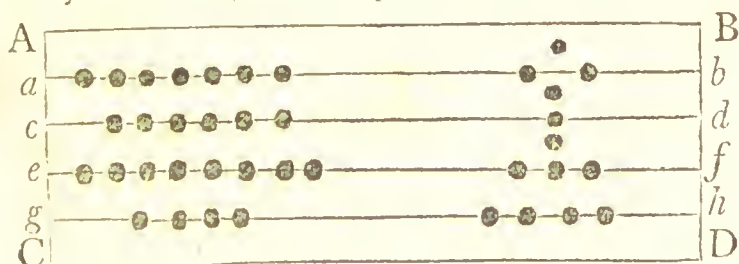
17. In all permutations, if the series 1, 2, 3, 4, &c. be continued to as many terms as there are quantities to be changed, and those terms be multiplied into each other, the product will be the number of permutations sought. Thus, if you would
know

know how many permutations can be formed with five quantities, multiply the terms, 1, 2, 3, 4, 5, together, and the product 120 will be the number of all the permutations*.

Previous to the numerical Recreations, we shall here describe certain mechanical methods of performing arithmetical operations, such as are not only in themselves entertaining, but will be found useful on several occasions.

The ROMAN ABACUS.

ON a board about a foot long, and of the form of *ABCD* in the following figure, draw several lines, as *ab*, *cd*, *ef*, *gh*, &c. the number of these lines may be increased at pleasure.



* For farther examples of combinations and permutations, see Recreations XVIII. XIX. &c.

On

On each of these lines, and on the spaces between them, there are to be placed a certain number of counters, according to the sum or quantity that is to be set down. The counters on the lowest line stand for units, those on the second line for tens, those on the third for hundreds, &c. and the counters between the lines stand always for half the value of those on the line next above. Therefore if you would set down 7684, you place four counters on the lowest line, eight on the next above, six on the next, and seven on the uppermost line. Or you may set down the same sum by placing part of it on the lines, and the rest between them, as you see in the figure.

To add or subtract by this instrument is very easy, as nothing more is necessary than to set on, or take off, a certain number of counters; or place those already on, higher or lower, according to the sum that is to be expressed.

By

By this invention a person who has not learned to write may set down any sum of money, or other quantity whatever ; for the counters on the several lines, instead of tens, hundreds, &c. may stand for hundred weights, quarters, pounds ; or for years, months, days, hours, &c. and, according to the length of the board, several sums of different denominations may be set down at the same time.

NEPER'S RODS.

DIVIDE a square piece of brass, ivory, or pasteboard, as A B C D, (Pl. I. Fig. 1.) into ninety-nine equal parts, as in the figure : in the nine parts next the left hand write the nine digits : in those next the right hand write nine cyphers, and in those at top the nine digits. Separate the remaining divisions into two parts, by a line drawn from the upper angle on the right side, to the lower angle on the left, and on these divisions write
 the

the multiplication table, observing when there are two figures, to place the units in the right hand division, and the tens in the left. Then separate the eleven columns by cutting them afunder from top to bottom, and you will have Neper's rods or bones*.

These rods are to be placed in a box of the length and depth of the square ABCD, and wide enough to hold six, nine, or as many more of each sort as you please. The uppermost figure of each rod must stand out, above the box, that it may be easily distinguished. The rods have sometimes figures on each of their four sides to answer different purposes. On the front of the box there must be a ledge to support the rods as they are taken out and placed in order.

To multiply any sum by these rods, suppose 5487 by 273, first, take out the

* So called from the inventor J. Neper, baron of Merchiston in Scotland.

index rod of digits next the left hand, and place it against the ledge; then take each of those rods that have at top one of the figures of the multiplicand, beginning with the figure 5, and place them in order as you will see in Pl. I. Fig. 2. You are then to set down the sum that stands against each figure of the multiplier, with this caution, that when there are two figures in any square, you are to add that in the left division to the figure in the right division of the following square, beginning with the right hand column. For example, in the column that stands against 3 in the digits (Fig. 2.) you first set down the 8, and carrying the 1 to the 4 in the next division, you set down 5; then adding the 2 on the second division to the 2 in the third, you set down 4; then adding 1 to 5, you set down 6, and lastly the figure 1. This may be done almost as fast as you can copy the figures; and so of the other figures in the multiplier, and the operation will stand as follows:

5486

$$\begin{array}{r}
 5486 \\
 273 \\
 \hline
 16458 \\
 38402 \\
 10972 \\
 \hline
 1497678 \\
 \hline
 \end{array}$$

To divide by these rods, suppose 748524 by 2793, place the rods that contain the several figures of the divisor, with the index rod, in the same manner as in the last example, and you will have the product of that divisor by each of the nine digits. Then take the first four figures of the dividend 7485, and look for that number on the rods which is the next less to it; which you will find to be 5586, that stands against the figure 2; you therefore put 2 for the quotient, and subtracting the last number from the first; bring down another figure from the dividend. You then look again for the nearest sum to that, and so on till you have taken down all the figures of the dividend,

when

when you will find the whole quotient to be 268.

The CHINESE SWAN PAN.

IN the square frame of wood, *ABCD*, (Pl. I. Fig. 3.) make four divisions by the bars, *EF* and *GH*; and separate three of these divisions into two parts by the lesser bars, *a b*. In each of the smaller divisions place wires, to be taken out at pleasure; and on each of the wires in the left-hand divisions, string a small ivory ball, or large bead; and on the wires on the right hand division, place four such balls, or beads.

The balls in the left hand divisions, when brought up to the middle bar, stand each for five; and those in the right divisions, when brought to the bar, stand for units.

The balls in the two lower divisions represent integers, or the whole of any

R E C R E A T I O N I.

Any number being named, by adding a figure to that number to make it divisible by nine.

IF the number named be, for example, 72,857, you tell him who names it to place the number 7 between any two figures of that sum, and it will be divisible by 9. For by aphorism 9, if any number be multiplied by 9, the sum of the figures of the product will be either 9, or a number divisible by 9. But the sum of the figures named is 29, therefore 7 must be added to it to make it divisible by 9.

You may diversify this recreation, by specifying, before the sum is named, the particular place where the figure shall be inserted, to make the number divisible by 9.

R E C R E -

RECREATION II.

A person having an even number of counters in one hand, and an odd number in the other, to tell in which hand the odd or even number is.

LET the person multiply the number in his right hand by an odd number, and the number in his left hand by an even number, and tell you if the sum of the products added together be odd or even. If it be even, the even number is in the right hand; but if it be odd, the even number is in the left hand: as is evident from the first five aphorisms.

Example.

i. Number in the right hand	} 18	In the left	7
Multipliers	3		2
	<hr/>		<hr/>
	54		14
	14		
	<hr/>		
Their sum	68		
	<hr/>		
	C 4	2. Num-	

By this instrument all the operations of arithmetic may be readily performed: suppose, for example, you would multiply the sum set down in the division of integers, that is 279 by 3. Begin with the lowest line, and say 3 times 2 is 6, therefore set that number up; then on the next row, say 3 times 7 is 21, therefore instead of 7 set up 1 on that line, and carry the two tens to the line below, which will make the number there 8. Then at the upper line say, 3 times 9 is 27, therefore set 7 on that line, and carry 2 to the next line below, which will make that number 3. So that the balls on the three lines will then express 837.

If you would divide 279 by 3, begin in like manner with the lowest line; but as 3 cannot be taken in 2, you add the next number to it, and say the threes in 27 are 9, therefore set back the 2 on the lowest line, and place 9, instead of 7, on the next line above; then at the uppermost line

Fig. 1. p 13.

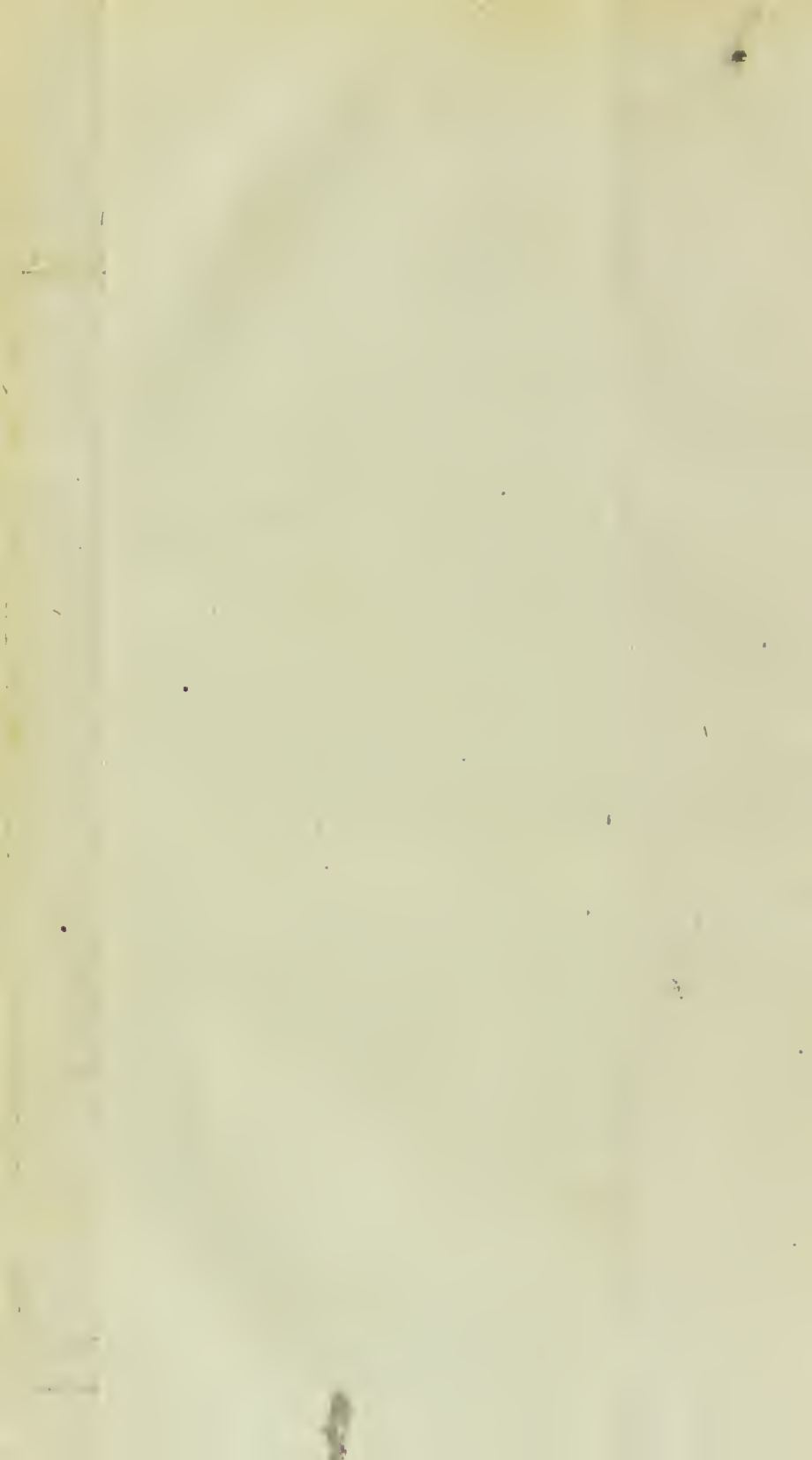
A	1	1	2	3	4	5	6	7	8	9	0	B
	2	2	4	6	8	10	12	14	16	18	0	
	3	3	6	9	12	15	18	21	24	27	0	
	4	4	8	12	16	20	24	28	32	36	0	
	5	5	10	15	20	25	30	35	40	45	0	
	6	6	12	18	24	30	36	42	48	54	0	
	7	7	14	21	28	35	42	49	56	63	0	
	8	8	16	24	32	40	48	56	64	72	0	
C	9	9	18	27	36	45	54	63	72	81	0	D

Fig. 2. p 15.

1	5	4	8	6
2	10	8	16	12
3	15	12	24	18
4	20	16	32	24
5	25	20	40	30
6	30	24	48	36
7	35	28	56	42
8	40	32	64	48
9	45	36	72	54

Fig. 3. p 17.

Parts		Units	
Tens		Units	
a		a	
b		b	
Integers		Units	
a		Units	
b		Tens	
		Hundreds	
		Thousands	
		Tens Thousands	
		Hund. Thousands	
		Millions	
C	T	D	H



line say, the threes in 9 are 3; therefore instead of 9 place 3 on that line, and consequently the quotient will be 93. When there is a remainder it may be placed with the divisor, as a fraction, in the upper divisions. When there are many figures in the multiplicand and multiplier, the latter may be placed in the two first divisions of parts, and the former and products in the divisions of integers. In like manner, when there are several figures in the dividend and divisor, the former may be placed in the division of integers, the latter in the first two divisions of parts, and the figures of the quotient as they rise, in the remaining two divisions.

It is well worth observing, that by means of this instrument a blind man may be taught to add, subtract, multiply, divide, and perform all the other operations of arithmetic, with as much certainty as another person can by figures.

quantity; those on the uppermost wire stand for tens of such integers, the next for hundreds, and so on, as is expressed, in the figure. The wires in all the divisions, may be increased to any number you think proper.

The balls in the four upper divisions represent parts of integers; those in the two divisions next the left hand stand for tens; and those in the two other divisions, for units of such parts*.

Now if the sum you would set down be integers, begin with the balls in the two lower divisions; for example, on the third row from the top bring two balls, of the right hand division, up to the middle bar (see the Figure); then bring up two on the next row, and one on the same row in the left division; next four on the
top

* This is not the original Swan Pan mentioned by Du Halde, in his History of China, but an improvement on that by Mr. G. Smethurst, of Manchester, published in the Gent. Mag. for 1743.

top row, and one on the other side of the same row; then in the first row of units, from the bottom, and in the right hand division, place two balls, on the second row one, and one also on the same line in the right hand division of tens: lastly, on the third row of units place three balls. The balls being thus placed, if the integers be pounds sterling, they will express 279l. 2s. 11 $\frac{3}{4}$ d. If the integers be hundred weights, the sum will be 279 cwt. 2 qrs. 11lb. 3oz. or if they be years, they will denote 279 years, 2 months, 11 days, 3 hours.

A part of these balls may represent fractions, either vulgar or decimal; the balls in the first two divisions of parts may stand for the numerators, and those in the other two for denominators; or the numbers in either of these divisions may be added to those in the integers, as decimals*.

* There may also be holes made in the bars where the dots are placed, in which pegs may be occasionally put, to shew that those numbers stand for fractions.

2. Number in the right hand	} 7	In the left	18
Multipliers	3		2
	<hr/>		<hr/>
	21		36
	36		
	<hr/>		
Their sum	57		
	<hr/>		

R E C R E A T I O N III.

A person making choice of several numbers, another shall name him the number by which the sum of those numbers is divisible.

PROVIDE a small bag, divided into two parts: in one part put several tickets, on each of which is wrote a number divisible by three, as 6, 9, 15, 36, 63, 120, 213, 309, &c. and in the other part put tickets marked with the number 3 only. From the first part draw a handful of tickets, and after shewing them, put them in again; then open the bag, and desire any one to take out as many tickets as he thinks

thinks proper; shut the bag, and when you open it again offer the other part to another person, telling him to take out one ticket only: you then pronounce that ticket to contain the number by which the amount of the other numbers is divisible. For each of those numbers being divisible by 3 their sum also, by aphorism 7, must be divisible by the same number.

RECREATION IV.

To find the difference between two numbers, the greatest of which is unknown.

TAKE as many nines as there are figures in the smallest number, and subtract that sum from the number of nines. Let another person add that difference to the largest number, and taking away the first figure of the amount, add it to the last figure, and that sum will be the difference of the two numbers*.

* See the eighth aphorism.

27, their products will terminate with the nine digits in this order, 9, 8, 7, 6, 5, 4, 3, 2, 1; the numbers being as follows, 219, 438, 657, 876, 1095, 1314, 1533, 1752, 1971; therefore put into one of the divisions of the little bag, mentioned in the third Recreation, several tickets marked with the number 73, and in the other part of the bag the numbers 3, 6, 9, 12, 15, 18, 21, 24, and 27.

Then open that part of the bag where are the numbers 73, and desire a person to take out one ticket only, then dextrously change the opening, and desire another person to take a ticket from that part, and when you have multiplied their two numbers together, by knowing the last figure of the product you will readily tell them by the foregoing series, what the other figures are.

RECREATION VIII.

The Magical Century.

IF the number 11 be multiplied by any one of the nine digits, the two figures of the product will always be similar. As follows:

11	11	11	11	11	11	11	11	11
1	2	3	4	5	6	7	8	9
—	—	—	—	—	—	—	—	—
11	22	33	44	55	66	77	88	99

Place a parcel of counters on a table, and propose to any one to add, alternately, a certain number of those counters, till they amount to a hundred, but never to add more than 10 at one time. You tell him, moreover, that if you stake first he shall never make the even century, but you will. In order to which you must first stake 1, and remembering the order of the above series, 11, 22, 33, &c. you constantly add, to what he stakes, as many as will make one more than the number of that series, that is, as will make 12, 23, 34, &c.

17 will necessarily end at 8, which shews that to be the hour he chose.

That the hour at which the counting ends must be that on which he proposed to rise, will be evident on a little reflection; for if he had begun at that hour and counted 12, he would necessarily have come to it again; and calling the number 17, by adding 5 to it, only serves to disguise the matter, but can make no sort of difference in the counting.

R E C R E A T I O N VI.

A person chusing any two, out of several given numbers, and after adding them together, striking out one of the figures from the amount, to tell you what that figure was.

SUCH numbers must be offered as are divisible by 9; and when any two of them are added together there must be no cypher in the amount: the figures of that amount,

amount, moreover, must make either 9 or 18. Such are the numbers following; 36, 63, 81, 117, 126, 162, 207, 216, 252, 261, 306, 315, 360, and 432.

These numbers must be wrote on cards; and when any two of them are added together, if a figure be struck out of the sum, it will be what would make the other figures either 9 or 18. For example; if a person chose 126 and 252, their sum will be 378, from which if he strikes out the 7, the remaining figures 3 and 8 will make 11, to which 7 must be added to make 18.

RECREATION VII.

Two persons chusing two numbers, and multiplying them together, by knowing the last figure of the produēt to tell the other figures.

IF the number 73 be multiplied by the numbers of the following arithmetical progressions, 3, 6, 9, 12, 15, 18, 21, 24, and

For example, Matthew, who is 22, tells Henry, who is older, that he can discover the difference of their ages; he therefore privately deducts 22 from 99, and the difference, which is 77, he tells Henry to add to his age, and to take away the first figure from the amount, and add it to the last figure, and that last sum will be the difference of their ages, As thus:

The difference between Matthew's	}	77
age and 99 is		
To which Henry adding his age		35
		<hr/>
The sum is		112
		<hr/>
		12
		1
		<hr/>
Then by taking away the first fi-	}	13
gure 1 and adding it to the last		
figure 2, the sum is		
Which added to Matthew's age		22
		<hr/>
Gives the age of Henry, which is		35
		<hr/>

R E C R E A T I O N V.

To tell, by the dial of a watch, at what hour any person intends to rise.

LET the person set the hand of the dial to any hour he please, and tell you what hour that is, and to the number of that hour you add, in your mind, 12. Then tell him to count privately the number of that amount upon the dial, beginning with the next hour to that on which he proposes to rise, and counting backwards, first reckoning the number of the hour at which he has placed the hand. An example will make this plain.

Suppose the hour at which he intends to rise be 8, and that he has placed the hand at 5. You add 12 to 5, and tell him to count 17 on the dial, first reckoning 5, the hour at which the index stands, and counting backwards from the hour at which he intends to rise, and the number

&c. till you come to 89, after which the other party cannot make the century himself, or prevent you from making it.

If the other party has no knowledge of numbers, you may stake any other number first, under 10, provided you take care to secure some one of the last terms, as 56, 67, 78, &c.

This Recreation may be performed with other numbers; and in order to succeed, you must divide the number to be attained, by a number that has one digit more than what you can stake each time, and the remainder will be the number you must first stake. Observe, that to be sure of success, there must be always a remainder. Suppose, for example, the number to be attained is 52, making use of a pack of cards instead of counters, and that you are never to add more than 6; then divide 52 by the next number above 6, that is, by 7, and the remainder, which
is

is 3, will be the number you must stake first; and whatever the other stakes, you must add as much to it as will make it equal to the number by which you divided, that is, 7. Therefore if his first stake be 1, you must stake 6, &c. so that your second stake will make the heap 10, your third stake will make it 17, and so on, till you come to 45, when as he cannot stake more than 6, you must make the number 52.

In this, as in the former case, if the other person have no knowledge of numbers, you may stake any number first under 7; or you may let him stake first, only taking care to secure either of the numbers 10, 17, 24, 31, &c. after which he cannot make 52, if you constantly add as many to his stake as will make it 7.

R E C R E A T I O N IX.

The Confederate Counters.

PRESENT to three persons a ring, a seal, and a snuff-box, of which desire each person to chuse one, privately. The three persons you discriminate in your mind by the letters A, E, I, and by the same letters you distinguish the ring, the seal, and the box. Provide 24 counters, of which give the first person A, 1, the second person E, 2, and the third person I, 3. Put the 18 remaining counters on the table, and let him that has the ring take as many counters more as he already has; him that has the seal take twice as many as he has, and him that has the box four times as many. While they are taking the counters you retire out of sight, and when they have done you return, and casting your eye on the table, take notice how many counters are left.

The

The remaining counters will be either 1, 2, 3, 5, 6, or 7, which you are to refer to the vowels in the syllables of the following verse:

1 2 3 5 6
 { { { { {
 Parfer—Cefar—ja dis—de vint—si grand
 7
 {
 prince.

If there be but one counter left, the two vowels in the syllables *par fer* denote that the first person has the ring, to which you have assigned the letter A; the second person has the seal, to which you have assigned the letter E; and consequently the third person must have the box. In like manner, if there be six counters remaining, the two vowels in the syllables *si grand*, shew that the first person has the box, denoted by the letter I; the second person has the ring, to which the letter A is assigned; and consequently the third person has the seal: and so of the rest.

It appears by aphorism 16, that the three articles can be taken only fix different ways. Now each of these ways necessarily changes the number of counters to be taken by the three persons: from whence it follows, that the counters remaining on the table will also be of fix different numbers; the vowels in the syllables of the verse serve only to aid the memory in discovering the manner in which the three articles are taken.

R E C R E A T I O N X.

A person privately fixing on any number, to tell him that number.

AFTER the person has fixed on a number, bid him double it and add 4 to that sum, then multiply the whole by 5; to the product let him add 12, and multiply the amount by 10. From the sum of the whole let him deduct 320, and tell you the remainder, from which, if you
cut

cut off the two last figures, the number that remains will be that he fixed on.

Example.

Let the number chose be	—	—	7
Which doubled is	—	—	14
And 4 added to it makes	—	—	18
Which multiplied by 5, gives	—		90
To which 12 being added, it is			102
That multiplied by 10, makes			1020
From which deducting 320, the			
remainder is	—	—	700
And by striking off the two cy-			
phers, it becomes the original			7
number	—	—	

R E C R E A T I O N XI.

Three dice being thrown on a table, to tell the number of each of them, and the order in which they stand.

LET the person who has thrown the dice double the number of that next his left hand, and add 5 to that sum; then multiply the amount by 5, and to the product add the number of the middle die; then let

D 3 the

the whole be multiplied by 10, and to that product add the number of the third die. From the total let there be subtracted 250, and the figures of the number that remains will answer to the points of the three dice as they stand on the table.

Example.

Suppose the points of the three dice thrown on the table to be 4, 6, and 2.

Then the double of the first die will be 8

To which add — — — 5

13

5

That sum multiplied by 5 will be 65

To which add the number of the }
middle die — — }

71

And multiply the sum by $\frac{7}{10}$

710

To that product add the number
of the third die — — } 2

712³

And from the total subtracting 712
250

The three remaining figures 462

will answer to the numbers on the dice, and shew the order in which they stand.

RECRE-

RECREATION XII.

*To tell the number a person has fixed on,
without asking him any questions.*

THE person having chose any number from 1 to 15, he is to add 21 to that number, and triple the amount. Then

1. He is to take the half of that triple, and triple that half.

2. To take the half of the last triple, and triple that half.

3. Take the half of the last triple.

4. Take the half of that half.

In this operation it appears there are four cases or stages where the half is to be taken: the three first are denoted by one of the eight following Latin words, each word being composed of three syllables, and those that contain the letter *i*, refer to those cases* where the half cannot be taken

* These cases being different in all the numbers that can be chose, they are thereby distinguished.

without a fraction; therefore in those cases the person who makes the deduction is to add 1 to the number to be divided. The fourth case shews which of the two numbers annexed to every word, has been chosen; for if the fourth half can be taken, without adding 1, the number chose is in the first column, but if not, it is in the second column.

The words.	The numbers they denote.	
Mi-fe-ris	8	0
Ob-tin-git	1	9
Ni-mi-um	2	10
No-ta-ri	3	11
In-fer-nos	4	12
Or-di-nes	13	5
Ti-mi-di	6	14
Te-ne-ant	15	7

Example.

Example.

Suppose the number chose to be	9
To which is to be added	1
	<hr/>
	10
Then the triple of that number is	30
The half of which is	15
The triple of that half must be	45
And the half of that*	23
The triple of that half	69
The half of that*	35
And the half of that half*	18

While the person is performing the operation, you remark, that at the second and third stage he is obliged to add 1. and consequently that the word *ob-tin-git*, in the second and third syllables of which is an *i*, denotes that the number must be either 1 or 9; and by observing that he cannot take the last half without adding 1, you know that it must be the

* At all the stages thus marked, 1 must be added in order to take the half without a fraction.

number in the second column. If he should make no addition at any one of the four stages, the number he chose must be 15, as that is the only number that has no fraction at either of the divisions.

R E C R E A T I O N XIII.

Thirty soldiers having deserted, fifteen of whom are to be punished; so to place the whole number in a ring, that you may save any fifteen you please, and it shall seem to be the effect of chance.

THE men must be placed according to the numbers annexed to the vowels in the words of the following verse:

Po-pu-le-am vir-gam ma-ter re-gi-na
 4 5 2 1 3 1 1 2 2 3 1
 fe-re-bat.
 2 2 1

Therefore you place 4 of those you would save first, then 5 of those you would punish, then 2 of those to be saved, and 1
 to

to be punished; and so on*. You then enter the ring, and beginning with the first of the four men you intend to save, you tell 9, and the ninth man is turned out to be punished. You go on telling 9 more, and the second 9 will fall on one you intend to punish; and so of the rest.

RECREATION XIV.

Some person in company having put a ring privately on one of his fingers; to name the person, the hand, the finger, and the joint, on which it is placed.

LET a third person double the number of the order in which he stands who has the ring, and add 5 to that number; then multiply that sum by 5, and to the product add 10. Let him next add 1 to last number if the ring be on the right hand, and 2 if on the left, and multiply the whole by 10: to this product he must

* You will observe that each vowel denotes the number that is to be placed, as *a* 1, *e* 2, *i* 3, &c.

add the number of the finger (counting the thumb as the first finger) and multiply the whole again by 10. Let him then add the number of the joint; and, lastly, to the whole join 35.

He is then to tell you the amount of the whole, from which you are to subtract 3535; and the remainder will consist of four figures, the first of which will express the rank in which the person stands, the second the hand (the number 1 signifying the right hand, and 2 the left), the third number the finger, and the fourth the joint.

Example.

Suppose the person who stands the third in order has put the ring upon the second joint of the thumb of his left hand; then

RECREATIONS. 45

The double of the rank of the } 6
third person is

To which add 5

11

Multiply the sum by 5

55

To which add 10

And the number of the left hand 2

67

Which being multiplied by 10

670

To which add the number of the thumb 1

671

And multiply again by 10

6710

Then add the number of the joint 2

And lastly the number 35

6747

From which deducting 3535

The remainder is 3212

Of which, as we have said, the 3 denotes the third person, the 2 the left hand, the 1 the thumb, and the last 2 the second joint.

OF

Of arithmetical magic squares.

A Magical square of this sort consists of numbers in arithmetic progression, so disposed in parallel and equal ranks, that the sum of each row, taken either perpendicularly, horizontally, or diagonally, is equal; as in the second figure.

Fig. 1.

Natural square.

A		G		B
1	2	3	4	5
6	7	8	9	10
E	11	12	13	14
	15	F		
16	17	18	19	20
21	22	23	24	25
C		H		D

Fig. 2.

Magical square.

A				B
11	24	7	20	3
4	12	25	8	16
17	5	13	21	9
10	18	1	14	22
23	6	19	2	15
C				D

Any five of the sums in this magic square taken in a right line, make 65. You will observe that the five numbers in the diagonals A D and B C of the magical square, answer to the horizontal and vertical ranks E F and G H in the natural square; and that 13 is the central number of both squares.

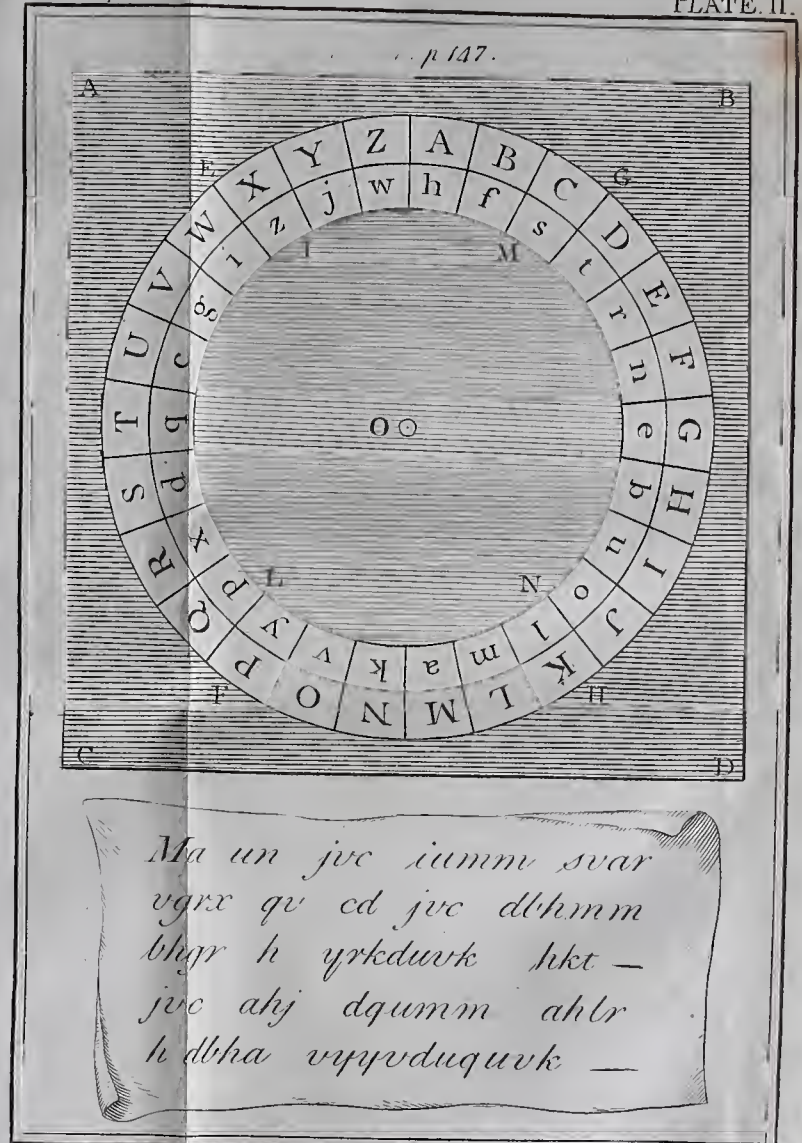
To

To form a magical square, first transpose the two ranks in the natural square, just mentioned, to the diagonals of the magic square; then place the number 1 under the central number 13, and the number 2, in the next diagonal downward. The number 3 should be placed next in the same diagonal line; but as there is no room in the square, you are to place it in that part it would occupy if another square were placed under this. For the same reason the number 4, by following the diagonal direction, falling out of the square, it is to be put in the part it would hold in another square, placed by the side of this: you then proceed to the numbers 5 and 6, still descending; but as the place 6 should hold is already filled, you then go back to the next diagonal, and consequently place the number 6 in the second case under the number 5, so that there may remain an empty case between the two numbers. The same method is to be taken whenever you find a case already filled.

You

You proceed in this manner to fill all the empty cases in the angle where the number 15 is placed; and as there is no place for the number 16 in the same diagonal descending, you must place it in the part it would hold in another square, and continue the same method till all the cases are filled. This method will serve equally for all sorts of arithmetic progressions composed of odd numbers*; those composed of even numbers being too complicate and abstruse for recreations.

* M. Ozanam, who has wrote very learnedly on magical squares, observes, that the Egyptians, and the Pythagoreans, their disciples, held them in great veneration. They were dedicated by them, he says, to the seven planets. Saturn had a square of nine cases assigned him; Jupiter, one of 16 cases; Mars, one of 25; Venus, 49; and Mercury, 64 cases: to the Moon they gave a square of 81 cases; and to the Deity, one of a single case, as unity can never be multiplied nor divided, but is for ever unchangeable.



RECREATION XV.

The series of numbers from 1 to 25 being wrote on that number of cards, after you have shuffled them, to deal them to five persons, either by twos or threes, at the option of the parties, and the amount of the numbers on each one's cards to be the same.

IN disposing these cards you must have recourse to the magical square in the last Recreation, and observe to put the two cards that have the numbers 11 and 4 at top; those cards that have 24 and 12 next, and so continue, by 2 and 2, to the last number of that rank, 16, which must be wrote on a card a little wider than the rest. You must follow the same method with the next three numbers 17, 10, 23, and so on to the last three 9, 22, 15, as is fully explained in the following table.

Cards.	Numbers.
1	11
2	4
3	24
4	12
5	7
6	25
7	20
8	8
9	3
10 wide card	16
11	17
12	10
13	23
14	5
15	18
16	6
17	13
18	1
19	19
20	21
21	14
22	2
23	9
24	22
25	15

The cards being thus disposed, or becoming so by being shuffled in the manner

ner we shall explain farther on, when we treat of the combination of cards, you offer to deal them by twos or threes first: if it be required to deal them by twos first, there is no occasion to cut them; but if they are to be dealt by threes, they must be cut, that he who cuts them may divide the pack exactly in that part where the wide card is, and that the fifteen cards that were at the bottom may be at top. Observe, you must feel the cards before you deal, in order to know if they be cut at the wide card; if not, they must be cut again, or you may cut them yourself.

It is evident by the foregoing table, which is formed after the magic square, that the numbers on each person's cards must necessarily amount to the same number, sixty-five.

RECREATION XVI.

To deal the 32 cards of the game of piquet to four persons, after you have shuffled them, and the parties have chose whether you shall deal by twos or threes; in such manner, that all the cards in each person's hand shall be of the same suit.

FIRST, dispose the cards in the following order, and observe that the eighth card must be a little larger than the rest.

1	Ace	} of Hearts.	First person.
2	Seven		
3	King	} Spades.	Second person.
4	Eight		
5	Knave	} Diamonds.	Third person.
6	Eight		
7	Ace	} Clubs.	Fourth person.
8	Knave		
wide card			
9	King	} Hearts.	First person.
10	Eight		
11	Nine		
12	Ace	} Spades.	Second person.
13	Knave		
14	Ten		
			15 Ace

15	Ace	}	Diamonds. Third person.
16	Seven		
17	Nine		
18	King	}	Clubs. Fourth person.
19	Ten		
20	Nine		
21	Queen	}	Hearts. First person.
22	Knave		
23	Ten		
24	Queen	}	Spades. Second person.
25	Nine		
26	Seven		
27	King	}	Diamonds. Third person.
28	Queen		
29	Ten		
30	Queen	}	Clubs. Fourth person.
31	Eight		
32	Seven		

You then follow the same method as in the preceding Recreation: if the cards are required to be dealt by twos first, they are not to be cut, but you deal, once two and twice three. If they are to be dealt by threes first, they must be cut at the place of the wide card, and then dealt by twice three and once two.

Of geometrical magic squares.

THE same method we have given for filling up the cases or divisions of an arithmetic magic square, is to be followed in these. We shall confine ourselves here to examples of the three following geometric squares, containing nine divisions each, which are filled up with three different progressions, applicable to the following Recreation.

Fig. 1.

16	512	4
8	32	128
256	2	64

Fig. 2.

24	768	6
12	48	192
384	3	96

Fig. 3.

56	179	214
28	112	448
896	7	224

You will observe, that in every geometric square, the product of the numbers in each row, whether taken vertically, horizontally, or diagonally, is constantly the same.

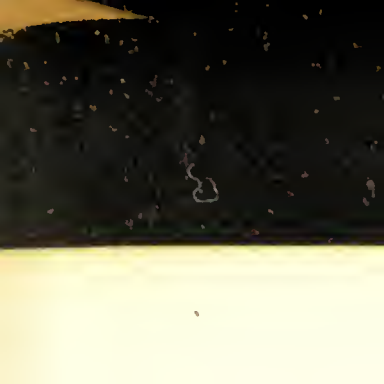
RECREATION XVII.

Several different numbers being wrote upon cards, to shuffle them, and deal the whole, or part of them, to three persons, in such manner that each one multiplying the numbers on his cards together, the product of each person's cards shall be the same; and to repeat the recreation after having shuffled the cards a second time.

WRITE upon seven-and-twenty cards the numbers that are in the foregoing squares, and dispose them in the following order:

1	16	First person.
2	512	Second person.
3	4	Third person.
4	8	1st person.
5	32	2d person.
6	128	3d person.
7	256	1st person.
8	2	2d person.
9 wide card	64	3d person.
10	24	1st person.
11	768	2d person.
12	6	3d person.





R E C R E A T I O N XVIII.

To find the number of changes that may be rung on twelve bells.

IT appears by the 17th aphorism, that nothing is more necessary here, than to multiply the numbers from 1 to 12 continually into each other, in the following manner, and the last product will be the number sought.

$$\begin{array}{r}
 1 \\
 2 \\
 \hline
 2 \\
 3 \\
 \hline
 6 \\
 4 \\
 \hline
 24 \\
 5 \\
 \hline
 120 \\
 6 \\
 \hline
 720 \\
 7 \\
 \hline
 5040 \\
 8 \\
 \hline
 40320 \\
 9 \\
 \hline
 362880 \\
 10 \\
 \hline
 3628800 \\
 11 \\
 \hline
 39916800 \\
 12 \\
 \hline
 479,001,600
 \end{array}$$

RECREATION XIX.

Suppose the letters of the alphabet to be wrote so small that no one of them shall take up more space than the hundredth part of a square inch: to find how many square yards it would require to write all the permutations of the 24 letters in that size.

BY following the same method as in the last recreation, the number of permutations of the 24 letters will be found to be

62,044,840,173,323,943,936,000

Now the inches in a square yard being 1296, that number multiplied by 100 gives 129600, which is the number of letter each square yard will contain; therefore if we divide 62,044,840,173,323,943,936,000 by 129600, the quotient, which is 478,741,050,720,092,160, will be the number of yards required, to contain the above mentioned number of permutations.

But





cards may be taken out of 52, and consequently the number sought.

The ARITHMETIC TRIANGLE.

Rank	A		B	
	1	2	1	2
1	1		1	
2	2		2	
3	3	1	3	1
4	4	2	4	2
5	5	3	5	3
6	6	4	6	4
7	7	5	7	5
8	8	6	8	6
9	9	7	9	7
10	10	8	10	8
11	11	9	11	9
12	12	10	12	10

The construction of this table is very simple. The line A *a* consists of the first twelve numbers. The line A *b* consists every where of units; and second term 3, of

of the line B c, is composed of the two terms 1 and 2 in the preceding rank: the third term 6, in that line, is formed of the two terms 3 and 3 in the preceding rank: and so of the rest; every term, after the first, being composed of the two next terms in the preceding rank; and by the same method it may be continued to any number of ranks. To find by this table how often any number of things can be combined in another number, under 13, as suppose 5 cards out of 8; in the eighth rank look for the fifth term, which is 56, and that is the number required.

Though we have shewn in the foregoing recreations the manner of finding the combination of all numbers whatever, yet as this table answers the same purpose, for small numbers, by inspection only, it will be found useful on many occasions; as will appear by the following recreations.

R E C R E A T I O N XXII.

To find how many different sounds may be produced by striking on a harpsichord two or more of the seven natural notes at the same time.

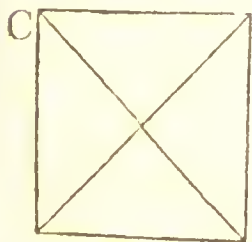
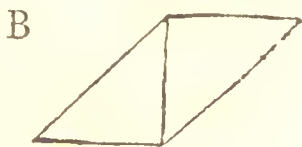
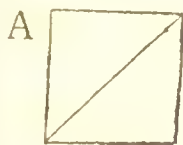
1. **T**HE combinations of two in seven, by the foregoing triangle are } 21
 2. The combinations of 3 in 7, are 35
 3. The combinations of 4 in 7, are 35
 4. The combinations of 5, are 21
 5. The combinations of 6, are 7
 6. The seven notes all together once 1
- Therefore the number of all the sounds will be } 120

R E C R E A T I O N XXIII.

Take four square pieces of pasteboard, of the same dimension, and divide them diagonally, that is by drawing a line from two opposite angles, as in the figures, into 8 triangles ;
paint

paint 7 of these triangles with the primitive colours, red, orange, yellow, green, blue, indigo, violet, and let the eighth be white. To find how many chequers or regular four-sided figures, different either in form or colour, may be made out of those eight triangles.

FIRST by combining two of these triangles there may be formed either the triangular square A, or the inclined square B, called a rhomb. Secondly, by combining four of the triangles, the large square C, may be formed; or the long square D, called a parallelogram.



Now the first two squares, consisting of two parts out of 8, they may each of them,

by the eighth rank of the triangle be taken 28 different ways, which makes 56. And the last two squares, consisting of four parts, may each be taken by the same rank of the triangle 70 times, which makes 140
 To which add the foregoing number 56
 and the number of the different
 squares that may be formed of } 196
 the eight triangles, will be

RECREATION XXIV.

A man has 12 different sorts of flowers, and a large number of each sort. He is desirous of setting them in beds or flourishes, in his parterre. Six flowers in some, 7 in others, and 8 in others; so as to have the greatest variety possible; the flowers in no two beds to be the same. To find how many beds he must have.

1. **T**HE combinations of 6 in 12
 by the last rank of the tri- } 924
 angles, are
2. The combinations of 7 in 12, are 792
3. The combinations of 8 in 12, are 495
 Therefore the number of beds } 2211
 must be

RECREATION XXV.

To find the number of chances that may be thrown on two dice.

AS each die has 6 faces, and as every face of one die may be combined with all the faces of the other, it follows, that 6 multiplied by 6, that is 36, will be the number of all the chances: as is also evident from the following table.

Points.										Numb. of chances.	Numb. of points.
2	1.1									1	2
3	2.1	1.2								2	6
4	3.2	3.1	1.3							3	12
5	4.1	1.4	3.2	2.3						4	20
6	3.3	5.1	1.5	4.2	2.4					5	30
7	6.1	1.6	5.2	2.5	4.3	3.4				6	42
8	4.4	6.2	2.6	5.3	3.5					5	40
9	6.3	3.6	5.4	4.5						4	36
10	5.5	6.4	4.6							3	30
11	6.5	5.6								2	22
12	6.6									1	12
										36	252

It appears by this table, 1. That the number of chances for each point continually encreases to the point of seven,

F 2

and

and then continually decreases till 12: therefore if two points are proposed to be thrown, the equality, or the advantage of one over the other, is clearly visible*.

2. The whole number of chances on the dice being 252, if that number be divided by 36, the number of different throws on the dice, the quotient is 7: it follows therefore, that at every throw there is an equal chance of bringing seven points. 3. As there are 36 chances on the dice, and only 6 of them doublets, it is 5 to 1, at any one throw, against throwing a doublet.

By the same method the number of chances upon any number of dice may be found: for if 36 be multiplied by 6, that

* It is easy from hence to determine whether a bet proposed at hazard, or any other game with the dice be advantageous or not; if the dice be true: which, by the way, is rarely the case for any long time together, as it is so easy for those that are possessed of a dexterity of hand to change the true dice for false.

product

product, which is 216, will be the chances on 3 dice; and if that number be multiplied by 6, the product will be the chances on 4 dice, &c.

RECREATION XXVI.

To discover the number of points on 3 cards, placed under three different parcels of cards.

YOU are first to agree that the ace shall tell eleven, the pictured cards ten each, and the others according to their number of points; as at the game of piquet. Then propose to any one to choose 3 cards, and over each of them to put as many cards as will make the number of the points of that card 15. Suppose, for example, he choose a 7, a 10, and an ace: then over the 7 he must place eight cards: over the 10, five cards, and over the ace, four. Take the remainder of the cards, and seeming to look for some card among them, tell how many there are,

F 3 and

and adding 16 to that number, you will have the number of points on the three cards. As in this instance, where there will remain 12 cards, if you add 16 to that number it will make 28, which is the number of points on the three cards*.

R E C R E A T I O N XXVII.

The ten duplicates.

TAKE twenty cards, and after any one has shuffled them, lay them down by pairs on the board, without looking at them. Then desire several persons to look each of them at different pairs, and remember what cards compose them. You then take up all the cards, in the order they lay, and place them again on the table, according to the order of the letters in the following words.

* If this Recreation be performed with a pack of quadrille cards, the number added to the remaining cards must be eight.

M U-

M U T U S

1 2 3 4 5

D E D I T

6 7 8 9 10

N O M E N

11 12 13 14 15

C O C I S*

16 17 18 19 20

Now you will observe that these words contain ten letters repeated, or ten pair of letters. Therefore you ask each person which row, or rows, the cards he looked at are in; if he say they are in the first row, you know that they must be the second and fourth: if in the second and fourth rows, they must be the ninth and nineteenth, and so of the rest.

* These words convey no meaning. The last word is sometimes wrote Coecis; but that being no Latin word, can make no sense with the others. If, indeed, it was Cæcis, a sort of sense might be made out: but then the æ would by no means answer the o in Nomen, as it must do to perform the Recreation.

R E C R E A T I O N XXVIII.

To name the number of cards that a person shall take out of the pack.

TO perform this Recreation you must so dispose a piquet pack of cards, that you can easily remember the order in which they are placed. Suppose, for example, that they are placed according to the words in the following line;

Seven aces, eight kings, nine queens, and ten knaves.

And that every card be of a different suit, following each other in this order; spades, clubs, hearts, and diamonds. Then the eight first cards will be the seven of spades, ace of clubs, eight of hearts, king of diamonds, nine of spades, queen of clubs, ten of hearts, and knave of diamonds; and so of the rest*.

* This Recreation may be farther diversified, by placing the cards in such manner, by the table for thirty-two numbers, that after they have been shuffled once or twice, they may come into the above order.

You

You ſhow that the cards are placed promiſcuouſly, and then offer them with the backs upward, to any one, that he may draw what quantity he pleaſe; which when he has done, you dexterouſly look at the card that precedes, and that which follows thoſe he has taken. After he has well regarded the cards, you take them from him, and putting them into different parts of the pack, ſhuffle them, or give them to him to ſhuffle. During which you recollect, by the foregoing line all the cards he took out: and as you lay them down, one by one, you name each card.

This is a pleaſing Recreation for thoſe that have a good memory; they that have not, ſhould never attempt it.

R E C R E A T I O N XXIX.

A century of different names being wrote on the cards, to tell the particular name which any person has thought on.*

ON ten cards write a hundred different names, observing only, that the last name on each card begin with one of the letters of the word, INDROMACUS, which letters, in the order they stand answer to the numbers 1, 2, 3, &c. to 10. On ten other cards write the same names, with this restriction, that the first name on every card must be taken from the first of the other cards, whose last name begins with I: the second name must be taken from that whose last name begins with N: and so of the rest. Then let any one choose a card out of the first ten, and after he has fixed on a name

* This is called the Impenetrable Secret; though it is one of the most easy Recreations with the cards.

give it you again, when you carefully note the last name, by which you know the number of that card. You then take the other ten cards, and after shuffling them, show them to the person one by one, and ask if he see the name he chose, and when he says he does, you look to that name which is the same in number from the top, with the number of the card he took from the other parcel, and that will be the name he fixed on. As for example, suppose he took out the card that had the word Daphnis at the bottom, which is the third card, and that he fixed on the name Galatea, then that word will necessarily be the third on the other card.

Order of the words on the first ten cards.

First Card Second Third Fourth

Celadon	Pomona	Deucalion	Licas
Andromeda	Omphalus	Hesiona	Calypso
Silenus	Ariadne	Galatea	Medea
Acis	Lilis	Thetis	Adonis
Eglea	Flora	Atys	Ceres
Sirincus	Danae	Palamedes	Cassandra
Thyrsis	Alcander	Melibæus	Pales
Polyphemus	Tiresias	Orion	Menelaus
Proteus	Ifforia	Nisus	Glaucus
Jason	Narcissus	Daphnis	Rophelina

Fifth Sixth Seventh Eighth

Latona	Icarus	Ganymede	Leander
Hilas	Clitander	Aristea	Peleus
Thistbe	Alcinous	Hyacinthus	Calista
Diana	Endimion	Circe	Cadmus
Palæmon	Alcidon	Mopsa	Psyche
Hebe	Iphis	Piramus	Semele
Sappho	Achelous	Philemon	Iphigenia
Acteon	Philomela	Astrea	Silvia
Medusa	Cephalus	Pelias	Alpheus
Orpheus	Mirtilus	Adrianus	Coridon

Ninth

Tenth

Hipolitus	Eson	Dryope	Isander
Corilas	Calistus	Nessus	Isidora
Procris	Arachne	Philoctetes	Melicerte
Caparissa	Pirus	Marfias	Riblis
Arethufus	Vertumnus	Licas	Silvander

Order

Order of the words on the last ten cards.

<i>First Card</i>	<i>Second</i>	<i>Third</i>	<i>Fourth</i>
Celadon	Andromeda	Silenus	Acis
Pomona	Omphalus	Ariadne	Lilis
Deucalion	Hesiona	Galatea	Thetis
Licas	Calypso	Medea	Adonis
Latona	Hilas	Thifbe	Diana
Icarus	Clitander	Alcinous	Endimion
Ganymede	Aristea	Hiacinthus	Circe
Leander	Peleus	Calista	Cadmus
Hypolitus	Corilas	Procris	Capariffa
Dryope	Nessus	Philoctetes	Marsias
<i>Fifth</i>	<i>Sixth</i>	<i>Seventh</i>	<i>Eighth</i>
Eglea	Sirineus	Thyrsis	Polyphemus
Flora	Danae	Alcander	Tiresias
Atys	Palamedes	Melibæus	Orian
Ceres	Cassandra	Pales	Menelaus
Palæmon	Hebe	Sappho	Adæon
Alcidon	Iphis	Archelous	Philomela
Mopsa	Piramus	Philemon	Astrea
Psyche	Semele	Iphigenia	Silvia
Arethufus	Eson	Calistus	Arachne
Licas	Isander	Isidora	Melicerte
<i>Ninth</i>		<i>Tenth</i>	
Proteus	Cephalus	Jafon	Myrtilus
Ifforia	Pelias	Narcissus	Adrianus
Nisus	Alpheus	Daphnis	Corydon
Glaucus	Pirus	Rophelina	Vertumnus
Medusa	Riblis	Orpheus	Silvander

Instead

Instead of ten cards, there may be twenty to each parcel, by adding duplicates to each card, which will make the Recreation appear the more mysterious, and will not at all embarrass it, as you have nothing to remember but the last name on each card. Or instead of names, you may write questions on one of the parcels, and answers on the other.

Of the combinations of the cards.

THE tables we here give are the basis of many recreations, as well on numbers, letters, and other subjects, as on the cards; and the effect here produced by them is the more surprising, as that which should seem to prevent any collusion, that is, the shuffling of the cards, is, on the contrary, the cause from whence it proceeds.

It is a matter of indifference what numbers are made use of in forming these tables. We shall here confine ourselves to such as are applicable to the subsequent
Recre-

Recreations. Any one may construct them in such manner as is agreeable to the purposes he intends they shall answer.

To make them, for example, correspond to the nine digits and a cypher, there must be ten cards, and at the top of nine of them must be wrote one of the digits, and on the tenth a cypher. These cards must be placed upon each other in the regular order, the number 1 being on the first, and the cypher at bottom. You then take the cards in your left hand, as is commonly done in shuffling, and taking off the two top cards, 1 and 2, you place the two following, 3 and 4, upon them; and under those four cards the three following 5, 6, and 7: at the top you put the cards 8 and 9, and at the bottom the card marked 0. Constantly placing in succession 2 at top and 3 at bottom, and they will then be in the following order:

8.9..3.4..1.2...5.6.7..0

If you shuffle them a second time, in the same manner, they will then stand in this order :

6.7..3.4..8.9..1.2.5..0

Thus, at every new shuffle, they will have a different order, as is expressed in the following lines:

1 shuffle	8.9.3.4.1.2.5.6.7.0
2	6.7.3.4.8.9.1.2.5.0
3	2.5.3.4.6.7.8.9.1.0
4	9.1.3.4.2.5.6.7.8.0
5	7.8.3.4.9.1.2.5.6.0
6	5.6.3.4.7.8.9.1.2.0
7	1.2.3.4.5.6.7.8.9.0

It is a remarkable property of this number, that the cards return to the order in which they were first placed, after a number of shuffles, which added to the number of columns that never change the order, is equal to the number of cards. Thus the number of shuffles is 7, and the number of columns in which the cards marked 3, 4, &c. never change their places is 3, which are equal to 10, the number of the cards.

cards. This property is not common to all numbers ; the cards sometimes returning to the first order in less number, and sometimes in a greater number of shuffles than that of the cards.

Though the cards are here directed to be shuffled by twos or threes only, yet tables may be constructed with equal facility for shuffling them by 2 and 1, 3 and 4, or any other number whatever ; observing that the fewer cards are taken together the less liable you will be to err.

Note, Before you venture to perform these Recreations, you should accustom yourself to shuffle the cards exactly and readily ; which will be easily attained by practice.

TABLES OF COMBINATIONS,
Constructed on the foregoing principles.

T A B L E I.*
FOR TEN NUMBERS.

Order before shuffling.	After 1st shuffle.	After the 2d.	After the 3d.
1	8	6	2
2	9	7	5
3	3	3	3
4	4	4	4
5	1	8	6
6	2	9	7
7	5	1	8
8	6	2	9
9	7	5	1
0	0	0	0

* These tables and the following Recreations at piquet, except the 36th, appear to have been composed by Mr. Guyot.

TABLE II.

FOR TWENTY FOUR NUMBERS.

Order before shuffling.	After 1st shuffle.	After the 2d	After the 3d.
1	23	21	17
2	24	22	20
3	18	12	2
4	19	15	7
5	13	5	13
6	14	6	14
7	8	9	3
8	9	3	18
9	3	18	12
10	4	19	15
11	1	23	21
12	2	24	22
13	5	13	5
14	6	14	6
15	7	8	9
16	10	4	19
17	11	1	23
18	12	2	24
19	15	7	8
20	16	10	4
21	17	11	1
22	20	16	10
23	21	17	11
24	22	20	16

T A B L E III.

FOR TWENTY SEVEN NUMBERS.

Order before shuffling.	After 1st shuffle.	After the 2d.	After the 3d.
1	23	21	17
2	24	22	20
3	18	12	2
4	19	15	7
5	13	5	13
6	14	6	14
7	8	9	3
8	9	3	18
9	3	18	12
10	4	19	16
11	1	23	21
12	2	24	22
13	5	13	5
14	6	14	6
15	7	8	9
16	10	4	19
17	11	1	23
18	12	2	24
19	15	7	8
20	16	10	4
21	17	11	1
22	20	16	10
23	21	17	11
24	22	20	16
25	25	25	25
26	26	26	26
27	27	27	27

TABLE IV.

FOR THIRTY TWO NUMBERS.

Order before shuffling. After the 1st shuffle. After the 2d. After the 3d.

1	28	26	22
2	29	27	25
3	23	17	7
4	24	20	12
5	18	10	9
6	19	11	3
7	13	1	28
8	14	2	29
9	8	14	2
10	9	8	14
11	3	23	17
12	4	24	20
13	1	28	26
14	2	29	27
15	5	18	10
16	6	19	11
17	7	13	1
18	10	9	8
19	11	3	23
20	12	4	24
21	15	5	18
22	16	6	19
23	17	7	13
24	20	12	4
25	21	15	5
26	22	16	6
27	25	21	15
28	26	22	16
29	27	25	21
30	30	30	30
31	31	31	31
32	32	32	32

R E C R E A T I O N X X X .

Several letters that contain no meaning, being wrote upon cards, to make them, after they have been twice shuffled, give an answer to a question that shall be proposed; as for example, What is Love?

LET 24 letters be wrote on as many cards, which, after they have been twice shuffled, shall give the following answer :

A dream of joy that soon is over.

First, write one of the letters in that line on each of the cards†. Then write the answer on a paper, and assign one of the 24 first numbers to each card, in the following order :

A D R E A M O F J O Y T H A T
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
 S O O N I S O ' E R .
 16 17 18 19 20 21 22 23 24

† These letters should be wrote in capitals on one of the corners of each card, that the words may be easily legible when the cards are spread open :

Next

Next, write on another paper a line of numbers, from 1 to 24, and looking in the table for 24 combinations you will see that the first number after the second shuffle is 21, therefore the card that has the first letter of the answer, which is A, must be placed against that number in the line of numbers you have just made* in like manner the number 22 being the second of the same column, indicates that the card which answers to the second letter, D, of the answer, must be placed against that number: and so of the rest. The cards will then stand in the following order:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
O	O	F	S	A	M	N	T	O	I	S	R	H	A	E	O	E
18	19	20	21	22	23	24										
J	O	R	A	D	Y	T										

From whence it follows that after these cards have been twice shuffled they must

* For the same reason if you would have the answer after one shuffle, the cards must be placed according to the first column of the table: or if after three shuffles, according to the third column.

infallibly stand in the order of the letters in the answer.

Observe 1. You should have several questions with their answers, consisting of 24 letters, wrote on cards : these cards should be put in cases, and numbered, that you may know to which question each answer belongs. You then present the questions ; and when any one of them is chose, you pull out the case that contains the answer, and shewing that the letters wrote on them make no sense, you then shuffle them, and the answer becomes obvious.

2. To make this Recreation the more extraordinary, you may have three cards on each of which an answer is wrote ; one of which cards must be a little wider, and another a little longer, than the others. You give these three cards to any one, and when he has privately chose one of them he gives you the other two, which you put into your pocket without looking at them,

them, having discovered by feeling which he has chose. You then pull out the case that contains the cards that answer to his question, and perform as before.

3. You may also contrive to have a long card at the botton, after the second shuffle. The cards may be then cut several times, till you perceive by the touch that the long card is at bottom, and then give the answer ; for the repeated cuttings, however often, will make no alteration in the order of the cards.

The second of these observations is applicable to some of the subsequent Recreations, and the third may be practised in almost all experiments with the cards. You should take care to put up the cards as soon as the answer has been shewn : so that if any one should desire the Recreation to be repeated, you may offer another question, and pull out those cards that contain the answer.

Though

Though this Recreation cannot fail of exciting at all times pleasure and surprize, yet it must be owned that a great part of the applause it receives arises from the address with which it is performed.

R E C R E A T I O N XXXI.

The twenty-four letters of the alphabet being wrote upon so many cards, to shuffle them, and pronounce the letters shall then be in their natural order; but that not succeeding, to shuffle them a second time, and then shew them in proper order.

WRITE the 24 letters on the cards
in the following order :

1	2	3	4	5	6	7	8	9	10	11	12
R	S	H	Q	E	F	T	P	G	U	X	C
13	14	15	16	17	18	19	20	21	22	23	24
N	O	D	Y	Z	I	K	&	A	B	L	M

The cards being disposed in this manner, shew them upon the table, that it may appear they are promiscuously marked.

ed. Then shuffle and lay them again on the table, pronouncing that they will be then in alphabetical order. Appear to be surpris'd that you have fail'd; take them up again and give them a second shuffle, and then counting them down on the table they will all be in their natural order.

RECREATION XXXII.

Several letters being wrote promiscuously upon 32 cards, after they have been once shuffled, to find in a part of them a question; and then shuffling the remainder a second time, to shew the answer.

SUPPOSE the question to be, *What is each Briton's boast?* and the answer, *His Liberty*; which taken together contain 32 letters.

After you have wrote those letters on 32 cards, write on a paper the words *his liberty*,

liberty, and annex to the letters the first ten numbers thus :

H I S L I B E R T Y

1 2 3 4 5 6 7 8 9 10

Then have recourse to the table of combinations for ten numbers, and apply the respective numbers to them in the same manner as in the 30th Recreation, taking the first column, as these are to be shuffled only once, according to that order.

1 2 3 4 5 6 7 8 9 10

I B S L E R T H I Y

This is the order in which these cards must stand after the whole numbers 32 has been once shuffled, so that after a second shuffle they may stand in their proper order. Next dispose the whole number of letters according to the first column for 32 letters : the last ten are to be here placed in the order above ; as follows,

WHAT IS EACH B R I T O N ' S

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

B O A S T ?

18 19 20 21 22

I B S L E R T H I Y

23 24 25 26 27 28 29 30 31 32

Therefore

Therefore, by the first column of the table, they will next stand thus :

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ITBRONSCHBO A E A S T long card															
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
I I S B S L I B E R T W H H I Y															

You must observe that the card here placed the 16th in order, being the last of the question, is a long card ; that you may cut them, or have them cut, after the first shuffle, at that part, and by that means separate them from the other ten cards that contain the answer.

Your cards being thus disposed, you show that they make no meaning ; then shuffle them once, and cutting them at the long card, you give the first part to any one, who reads the question, but can find no answer in the others, which you open before him ; you then shuffle them a second time, and shew the answer as above.

R E C R E A T I O N XXXIII.

To write 32 letters on so many cards, then shuffle and deal them by twos to two persons, in such manner, that the cards of one shall contain a question, and those of the other, an answer.

SUPPOSE the question to be, *Is nothing certain?* and the answer, *Yes, disappointment.*

Over the letters of this question and answer write the following numbers, which correspond to the order in which the cards are to be dealt by two and two.

I S N O T H I N G C E R T A I N															
31	32	27	28	23	24	19	20	15	16	11	12	7	8	3	4
Y E S D I S A P O I N T M E N T															
29	30	25	26	21	22	17	18	13	14	9	10	5	6	1	2

Then have recourse to the first column of the table for 32 numbers, and dispose

pose these 32 cards in the following order, by that column.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
O	I	E	R	G	C	A	N	T	P	I	N	T	A	I	S
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
T	M	E	H	S	D	I	N	N	O	Y	N	T	E	I	S

The cards being thus disposed, shuffle them once, and deal them 2 and 2 ; when one of the parties will necessarily have the question, and the other the answer.

Instead of letters you may write words upon the 32 cards, 16 of which may contain a question, and the remainder the answer ; or what other matter you please. If there be found difficulty in accommodating the words to the number of cards, there may be two or more letters or syllables wrote upon one card.

R E C R E A T I O N XXXIV.

The Five Beatitudes.

THE five blessings we will suppose to be, 1. Science, 2. Courage, 3. Health, 4. Riches, and 5. Virtue. These are to be found upon cards that you deal, one by one, to five persons. First write the letters of these words successively, in the order they stand, and then add the numbers here annexed to them.

S C I E N C E										C O U R A G E									
31	26	21	16	11	6	1				32	27	22	17	12	7	2			
H E A L T H										R I C H E S									
28	23	18	13	8	3					29	24	19	14	9	4				
V I R T U E																			
30	25	20	15	10	5														

Then range them in order agreeable to the first column of the table for 32 numbers, as in the last Recreation. Thus.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
L	H	N	A	T	E	R	E	U	A	C	R	G	T	I	U				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32				
E	E	C	I	I	C	H	S	O	H	R	E	E	V	S	C				

Next,

Next, take a pack of cards, and write on the four first the word Science ; on the four next the word Courage ; and so of the rest.

Matters being thus prepared, you shew that the cards on which the letters are wrote convey no meaning. Then take the pack on which the words are wrote, and spreading open the first four cards, with their backs upward, you desire the first person to choose one. Then close those cards and spread the next four to the second person ; and so to all the five ; telling them to hold up their cards lest you should have a confederate in the room.

You then shuffle the cards and deal them one by one, in the common order, beginning with the person who chose the first card, and each one will find in his hand the same word as is wrote on his card. You will observe, that after the sixth round of dealing, there will be two cards

left, which you give to the first and second persons, as their words contain a letter more than the others.

R E C R E A T I O N XXXV.

The cards of the game of piquet being mixed together, after shuffling them, to bring, by cutting them, all the cards of each suit together.

THE order in which the cards must be placed to produce the effect desired, being established on the same principle as that explained in the 31st Recreation, except that the shuffling is here to be repeated three times, we think it will be sufficient to give the order in which they are to be placed before the first shuffle.

Order of the Cards.

1 Ace	} clubs	17 King clubs
2 Knave		18 Ten
3 Eight	} diamonds	19 Nine
4 Seven		20 Seven clubs
wide card		
5 Ten clubs		21 Ace diamonds
6 Eight	} spades.	22 Knave spades
7 Seven		23 Queen hearts
wide card		
8 Ten	} diamonds.	24 Knave hearts
9 Nine		25 Ace spades
10 Queen		26 King diamonds
11 Knave		27 Nine clubs
12 Queen clubs		28 Ace
13 Eight	} hearts	29 King
14 Seven		30 Eight clubs
wide card		
15 Ten	} spades	31 King
16 Nine		32 Queen

You then shuffle the cards, and cutting at the wide card, which will be the seven of hearts, you lay the eight cards that are cut, which will be the suit of hearts, down on the table. Then shuffling the remaining cards a second time, you cut at the

second wide card, which will be the seven of spades, and lay, in like manner, the eight spades down on the table. You shuffle the cards a third time, and offering them to any one to cut, he will naturally cut them at the wide card*, which is the seven of diamonds and consequently divide the remaining cards into two equal parts, one of which will be diamonds and the other clubs.

RECREATION XXXVI.

The cards at piquet being all mixed together, to divide the pack into two unequal parts, and name the number of points contained in each part.

YOU are first to agree that each king queen and knave shall count, as usual, 10, the ace 1, and the other cards ac-

* You must take particular notice whether they be cut at the wide card, and if they are not, you must have them cut, or cut them again yourself.

cordova

cording to the number of the points. Then dispose the cards, by the table for 32 numbers, in the following order, and observe that the last card of the first division must be a wide card.

Order of the cards before shuffling.

1 Seven hearts	17 Nine diamonds
2 Nine clubs	18 Ace spades
3 Eight hearts	19 Ten clubs
4 Eight	20 Knave
5 Knave } spades	21 Eight } diamonds
6 Ten }	22 King }
7 Queen } clubs	23 Seven spades
8 Ace }	24 Seven } diamonds
9 Ace hearts	25 Queen }
wide card	
10 Nine hearts	26 Knave hearts
11 Queen spades	27 King clubs
12 Knave clubs	28 Nine } spades
13 Ten diamonds	29 King }
14 Ten }	30 Ace diamonds
15 King } hearts	31 Seven } clubs
16 Queen }	32 Eight }

You then shuffle them carefully, according to the method before described, and they will stand in the following order.

Cards.	Numbers.	Cards.	Numbers.
		Brought up	34
1 Nine } Spades	9	6 Ten clubs	10
2 King }	10	7 Ten diamonds	10
3 Seven }	7	8 Ten hearts	10
4 Seven diamonds	7	9 Ace clubs	1
5 Ace spades	1	10 Ace hearts (wide card)	1
Carried up	<u>34</u>	Total	<u>66</u>
		Brought up	101
11 Eight Hearts	8	22 Queen hearts	10
12 Eight spades	8	23 Nine }	9
13 Seven hearts	7	24 Knave }	10
14 Nine clubs	9	25 Eight }	8
15 Knave } Spades	10	26 King }	10
16 Ten }	10	27 Queen }	10
17 Queen clubs	10	28 Knave hearts	10
18 Nine hearts	9	29 King clubs	10
19 Queen spades	10	30 Ace diamonds	1
20 Knave clubs	10	31 Seven }	7
21 King hearts	10	32 Eight }	8
Carried up	<u>101</u>	Total	<u>194</u>

When the cards are by shuffling disposed in this order, you cut them at the wide card, and pronounce that the cards you have cut off contain 66 points, and consequently the remaining part 194. This recreation excites a good degree of admiration, but the applying of these cards to the next Recreation produces a much greater.

RECREATION XXXVII.

*The inconceivable repique**

WHEN you would perform this Recreation with the cards used in the last, you must observe not to disorder the first ten cards in laying them down on the table. Putting those cards together, in their proper order, therefore you shuffle them a second time in the same manner, and offer them to any one to cut, observing carefully if he cut them at the wide card, which will be the ace of hearts, and will then be at top ; if not you must make him, under some pretence or other, cut them till it is ; and the cards will then be ranged in such order that you will repique the person against whom you play, though you let him choose (even after he has cut) in what suit you shall make the repique.

* This manœuvre of piquet was invented by the Countess of L--- (a French lady), and communicated by her to M. Guyot.

Order of the cards after they have been shuffled and cut.

1 Eight hearts	17 Nine	} diamonds
2 Eight	18 Knave	
3 Knave	19 Nine hearts	} spades
4 Ten	20 Queen spades	
5 Queen	21 Seven hearts	} clubs
6 Knave	22 Nine clubs	
7 King	23 Ten hearts	} hearts
8 Queen	24 Ace clubs	
9 Eight	25 Seven spades	} diamonds
10 King	26 Seven diamonds	
11 Queen	27 Nine	
12 Ace	28 King	} spades
13 Seven	29 Ace	
14 Eight	30 Ten clubs	} clubs
15 Knave hearts	31 Ten diamonds	
16 King clubs	32 Ace hearts	(wide card)

The cards being thus disposed, you ask your adversary in what suit you shall re-pique him. If he say in clubs or diamonds you must deal the cards by threes, and the hands will be as follows :

Elder.

Hearts, king
 ——— queen
 ——— knave
 ——— nine
 ——— eight
 ——— seven
 Spades, queen
 ——— knave
 ——— eight
 Diamonds, eight
 Clubs, eight
 ——— seven

Younger.

Clubs, ace
 ——— king
 ——— queen
 ——— knave
 ——— nine
 Diamonds, ace
 ——— king
 ——— queen
 ——— knave
 ——— nine
 Spades, ten
 Hearts, ten

Rentree, or take in,
 of the elder.

Seven spades
 Seven diamonds
 Nine }
 King } spades
 Ace }

Rentree of the
 younger.

Ten clubs
 Ten diamonds
 Ace hearts

If he against whom you play, who is
 supposed to be elder hand, has named
 clubs for the repique, and has taken in
 five cards, you must then lay out the
 queen, knave, and nine of diamonds, and
 you

you will have, with the three cards you take in, a fixiem major in clubs, and quatorze tens. If he leave one or two cards, you must discard all the diamonds.

If he require to be repiqued in diamonds, then discard the queen, knave and nine of clubs; or all the clubs if he leave two cards; and you will then have a hand of the same strength as before.

Note, If the adversary should discard five of his hearts, you will not repique him, as he will then have a septiem in spades: or if he only take one card: but neither of these any one can do, who has the least knowlege of the game. If the person against whom you play would be repiqued in hearts or spades, you must deal the cards by twos, and the game will stand thus:

Elder hand.

King	}	diamonds
Knave		
Nine		
Eight		
Queen	}	clubs
Knave		
Nine		
Eight		
Seven	}	hearts
Eight		
Seven		
Eight		
spades		

Younger hand.

Ace	}	clubs
King		
Ace	}	diamonds
Queen		
Queen	}	spades
Knave		
Ten	}	hearts
King		
Queen		
Knave		
Ten	}	
Nine		

Rentree.

Seven	}	spades
Seven		
Nine		
King		
Ace		

Rentree.

Ten
clubs
Ten
diamonds
Ace
hearts

If he require to be repiqued in hearts, you keep the quint to a king in hearts, and the ten of spades, and lay out which of the rest you please: then, even if he should leave two cards, you will have a fixiem major in hearts, and quatorze tens, which will make a repique.

But

But if he demand to be repiqued in spades ; at the end of the deal you must dextrously pass the three cards that are at the bottom of the stock (that is, the ten of clubs, ten of diamonds, and ace of hearts) to the top*, and by that means you reserve the nine, king, and ace of spades for yourself : so that by keeping the quint in hearts, though you should be obliged to lay out four cards, you will have a fixiem to a king in spades, with which and the quint of hearts, you must make a repique.

Observe here likewise, that if the adversary lay out only three cards, you will not make the repique : but that he will never do unless he be quite ignorant of the game, or has some knowledge of your intention.

This last stroke of piquet has gained great applause, when those that have

* The manner of doing this you will find in the Appendix, among the Recreations of Dexterity.

publicly performed it, have known how to conduct it dextrously. Many persons who understand the nature of combining the cards, have gone as far as the passing the three cards from the bottom of the stock, and have then been forced to confess their ignorance of the manner in which it was performed.

R E C R E A T I O N XXXVIII.

The metamorphosed Cards.

PROVIDE thirty-two cards that are differently coloured; on which several different words are wrote, and different objects painted. These cards are to be dealt two and two, to four persons, and at three different times, shuffling them each time. After the first deal every one's cards are to be of the same colour : after the second deal, they are all to have objects that are similar ; and after the third, words that convey a sentiment.

Dispose

Dispose of the cards in the following order.

Order of the cards.	Colours.	Objects.	Words.
1	Yellow	Bird	I find
2	Yellow	Bird	In you
3	Green	Flower	Charming
4	Green	Flower	Flowers
5	White	Bird	To hear
6	White	Orange	Beauty
7	Red	Butterfly	My
8	Red	Flower	Notes
9	Red	Flower	In
10	Red	Butterfly	Shepherdes
11	Green	Butterfly	Lover
12	Green	Butterfly	Your
13	White	Flower	Of
14	White	Flower	an inconstant
15	Yellow	Orange	Image
16	Yellow	Flower	Inchanting
17	White	Orange	Ardor
18	Yellow	Butterfly	My
19	Yellow	Butterfly	Phyllis
20	White	Bird	Birds
21	Red	Orange	Sing
22	Red	Orange	Dear
23	Green	Orange	and Sweetness
24	Green	Orange	The
25	Green	Bird	Of

Order of the cards.	Colours.	Objects.	Words.
26	Green	Bird	Present
27	Yellow	Flower	As
28	Red	Bird	Changes
29	Red	Bird	Bosom
30	Yellow	Orange	Mc
31	White	Butterfly	Your
32	White	Butterfly	I long

The cards thus coloured, figured, and transcribed, are to be put in a case, in the order they here stand.

When you would perform this Recreation you take the cards out of the case, and shew, without changing the order in which they were put, that the colours, objects, and words are all placed promiscuously. You then shuffle them in the same manner as before, and deal them, two and two, to four persons, observing that they do not take up their cards till all are dealt, nor mix them together: and the eight cards dealt to each person will be found all of one colour. You then take
each

each person's cards, and put those of the second person under those of the first, and those of the fourth person under those of the third. After which you shuffle them a second time, and having dealt them in the same manner, on the first person's cards will be painted all the birds; on the second person's cards, all the butterflies; on those of the third, the oranges; and on those of the fourth, the flowers. You take the cards a second time, and observing the same precautions, shuffle and deal them as before, and then the first person, who had the last time the birds in his hands, will have the words in his hand that compose this sentence.

Sing dear birds, I long to hear your enchanting notes.

The second person, who had the last deal the butterflies, will now have these words,

Of an inconstant lover your changes present me the image.

The third, who had the oranges, will have this sentence.

As

*As in my Phylis, I find in you, beauty
and sweetness.*

The fourth, who had the flowers, will have these words,

*Charming flowers, adorn the bosom of my
sheperdess.*

It seems quite unnecessary to give any farther detail, as they who understand the foregoing Recreations will easily perform this.

RECREATION XXXIX.

The repique with carte blanc.

IN the following Recreations relating to piquet, we shall confine ourselves to the order in which the cards must stand after they are cut, and ready to be dealt. They who chuse to shuffle them first (in order to make the performance appear the more extraordinary) may easily dispose them in a proper order for that purpose, by having recourse to the table of combinations for 32 numbers.

Order of the cards.

Elder	1	Ace	} Spades
	2	Seven	
Younger	3	Seven clubs	
	4	Ten hearts	
E.	5	Ace hearts	
	6	Knave spades	
Y.	7	Nine hearts	
	8	Eight clubs	
E.	9	Queen spades	
	10	Ace diamonds	
Y.	11	Eight hearts	
	12	Eight spades	
E.	13	Queen diamonds	
	14	Ace clubs	
Y.	15	Nine diamonds	
	16	Nine clubs	
E.	17	King	} Diamonds
	18	Ten	
Y.	19	Seven hearts	
	20	Seven diamonds	
E.	21	Nine spades	
	22	Knave diamonds	
Y.	23	Ten clubs	
	24	Eight diamonds	

25 King hearts	} Elder's rentrée
26 King clubs	
27 Queen hearts	
28 King spades	
29 Ten spades	} Younger's rentrée
30 Queen clubs	
31 Knave clubs	
32 Knave hearts	

The cards being thus disposed, the hands of the players, after they have been dealt two and two, will be as follows.

Elder.

Younger.

Ace
Queen
Knave } spades
Nine
Seven }

Ace
King
Queen } diamonds
Knave
Ten }

Ace hearts
Ace clubs

Ten
Nine
Eight } clubs
Seven }

Ten
Nine
Eight } hearts
Seven }

Nine
Eight } Diamonds
Seven }
Eight spades

The Rentrée.

King } hearts
Queen }

King clubs

King } spades
Ten }

Queen } clubs
Knave }

Knave hearts

The cards being thus dealt, you desire the other player to cast his eye over the two hands, and take which he please, on condition, that if he keep the hand dealt him he shall be eldest ; but if he take the other he shall be youngest.

If he keep the hand dealt him, which in appearance is much preferable to the other, he will naturally lay out the four lowest spades, and leave a card, by carrying the quint in diamonds and four aces. You then tell down your carte blanche, and keeping the two quarts in clubs and hearts, lay out the others, and with your rentrée you will have a fixiem in clubs and a quint in hearts, with which you will make a repique, counting 107 points, though if the cards were played you would be capoted.

If the opposite player choose the youngest hand, you then discard the quart to a king in diamonds with the seven of
spades

spades, and with your rentrée you will have a fixiem major in spades, and quatorze of aces : by which you make repique and capot.

Here also you may miss the repique, if the other player keep the hand dealt him, and discard his diamonds ; but this as in the other cases, no one will do, who has any knowledge of the game.

RECREATION XL.

Case at piquet, where you repique the elder hand, though he have the choice of the cards after they are dealt.

THE cards must here stand, after they have been cut, in the following order.

Elder	1 Ace	} spades
	2 Eight	

Younger	3 Knave	} clubs
	4 Ten	

E.	5 Ace clubs
	6 Nine hearts

- Y. 7 Eight clubs
 8 Nine diamonds
 E. 9 Queen clubs
 10 Eight diamonds
 Y. 11 Seven clubs
 12 Ten diamonds
 E. 13 Ten Spades
 14 Eight hearts
 Y. 15 Nine } clubs
 16 King }
 E. 17 King } spades
 18 Queen }
 Y. 19 Knave diamonds
 20 Seven spades
 E. 21 Seven diamonds
 22 Knave spades
 Y. 23 Ace diamonds
 24 Nine spades
 25 King }
 26 Knave }
 Rentrée E. 27 Queen } hearts
 28 Seven }
 29 Ten }
 30 Ace hearts
 Rentrée Y. 31 Queen } diamonds
 32 King }

The cards being thus disposed * when they are dealt, the hands of the two players will be as follows.

Elder.	Younger.
Spades, ace	Diamonds, ace
——— king	——— knave
——— queen	——— ten
——— knave	——— nine
——— ten	Clubs, king
——— eight	——— knave
Clubs, ace	——— ten
——— queen	——— nine
Hearts, nine	——— eight
——— eight	——— seven
Diamonds, eight	Spades, nine
——— seven	——— seven

Rentrée.	Rentrée.
King	Ace, hearts
Queen	King
Knave	Queen } diamonds
Ten	
Seven	

You then give the other player the liberty of choosing either hand, but without

* In all these Recreations with piquet, there should be a wide card left, that they may be properly cut.

seeing them. If he chose the elder hand, you discard the king of clubs, with the nine and seven of spades, and by your *rentrée* you will have a *fixiem* in diamonds and the point which will make 22, and that added to the quint in clubs will make 97, and you will necessarily win, as the adversary will not fail to lay out his two small hearts.

If, on the contrary, he choose the younger hand, you discard the knave, ten and eight of spades, with the seven and eight of diamonds: then by taking in the quint to a king in hearts, you will have a *septiem* in hearts, a *tierce major* in spades, and three queens, which will tell 90, though the adversary should discard to the most advantage possible.

RECREATION XLI.

Case at piquet, where you give the other player not only the choice of the suite in which he will be repiqued, but that of dealing the cards by twos or by threes, and of taking either hand after they are dealt, you being to tell and play first.

THE cards must be disposed as follows:

1 Queen	} clubs	17 Queen	} spades
2 Nine		18 Nine	
3 Eight		19 Eight	
4 Seven		20 Seven	
wide card		wide card	
5 Ace	} hearts	21 Ace	} diamonds
6 King		22 King	
7 Knave		23 Knave	
8 Ten		24 Ten	
9 Queen		25 Queen	
10 Nine		26 Nine	
11 Eight		27 Eight	
12 Seven		28 Seven	
wide card		wide card	
13 Ace	} spades	29 Ace	} clubs
14 King		30 King	
15 Knave		31 Knave	
16 Ten		32 Ten	

It is evident by this disposition of the cards, that if they are cut at any one of the wide cards, which are the last of each suite, there will be always a flock of eight cards of the same suite. Consequently, if he with whom you play require to be repiqued in clubs, by cutting at the first wide card, which is the seven of clubs, the eight clubs will necessarily be at the bottom of the pack, and you will have for your rentrée a quint major in clubs. The same will happen in all the other suites, by cutting at the 7 of each. If he deal the cards by twos, the hands will be as follows*.

Elder		Younger	
Ace	} hearts	Knave	} hearts
King		Ten	
Queen		Eight	
Nine		Seven	
Ace	} spades	Knave	} spades
King		Ten	
Queen		Eight	
Nine		Seven	
Ace	} diamonds	Knave	} diamonds
King		Ten	
Queen		Eight	
Nine		Seven	

* The hands will be always the same, though in different suites.

Rentrée

Ace
 King
 Knave
 Ten
 Queen

} clubs

Nine
 Eight
 Seven

} clubs

But if he deal the cards by threes, the hands will stand thus:

Elder

Ace
 King
 Knave
 Seven

} hearts

Ace
 Queen
 Nine
 Eight

} spades

Knave
 Ten
 Queen

} diamonds

Younger

Ten
 Queen
 Nine

} hearts

King
 Knave
 Ten
 Seven

} spades

Ace
 King
 Nine
 Eight
 Seven

} diamonds

Rentrée.

Ace
 King
 Knave
 Ten
 Queen

} clubs

Nine
 Eight
 Seven

} clubs

If

If the other player require to be repiqued in spades, you cut them at the 7 of that suite, and tell him he is at liberty to deal them by twos or threes*. If he deal them by twos, he is to choofe which hand he will have, without feeing them; you being still eldest.

If he keep his own hand, you discard the nine of hearts, spades and diamonds, and either of the two queens; and by your rentrée you will have a quint major in clubs, quatorze aces, and quatorze kings, with which you make a repique. But if he choofe the cards dealt for the elder, you discard the seven of hearts, spades, and diamonds, and any two of the eights; and you will have by your rentrée the fame quint in clubs, quatorze queens and quatorze knaves; which will also make a repique.

* You are to take care he does not shuffle the cards; and the better to prevent it, you may so dispose them as to shuffle them before him, after the manner explained in some of the foregoing Recreations.

























If

If the adversary deal the cards by threes, and keep his hand, you discard the king, eight and seven of hearts, with the nine and eight of spades; and by your *rentrée* you will have the quint major in clubs, a tierce to a queen in diamonds, three aces, three queens, and three knaves, with which you make a *repique*. But if he choose the cards dealt for the elder, you discard the queen and nine of hearts, the knave and seven of spades, and the ace of diamonds, and you will then have the same quint in clubs, a tierce to a nine in diamonds, three kings and three tens, with which you will tell 29 points, therefore by playing one, you can in this case make a *pique* only.

R E C R E A T I O N XLII.

An exemplary case at piquet, where you re-pique your adversary, after giving him the choice of having the cards dealt either by twos or threes.

TO dispose the cards in the order necessary to produce the effect here required, and in all others where you give the choice of having the cards dealt either by twos or threes, you must have recourse to the following table.

Cards that will go to the eldest.	Numb. of the Cards.	Cards that will come to the youngest.	Variable cards.
1 	{ 1 }		
2 	{ 2 }		
	{ 3 }	- - -	3 
	{ 4 }	4 	
	{ 5 }	- - -	5 
	{ 6 }	- - -	6 
	{ 7 }	- - -	7 
	{ 8 }	- - -	8 
9 	{ 9 }		
	{ 10 }	- - -	10 
	{ 11 }	11 	
	{ 12 }	12 	
13 	{ 13 }		
14 	{ 14 }		
	{ 15 }	- - -	15 
	{ 16 }	16 	
	{ 17 }	- - -	17 
	{ 18 }	- - -	18 
	{ 19 }	- - -	19 
	{ 20 }	- - -	20 
21 	{ 21 }		
	{ 22 }	- - -	22 
	{ 23 }	23 	
	{ 24 }	24 	

This

This table shews the different hands that result from the two different methods of dealing the cards ; that the eldest hand has always, in some order or other, the six cards placed against the numbers, 1, 2, 9, 13, 14, and 21 : and the younger, the six cards placed against 4, 11, 12, 16, 23, and 24. It shows likewise, that the 12 cards marked 3, 5, 6, 7, 8, 10, 15, 17, 18, 19, 20, and 22, may be in either hand, so far as concerns the manner of dealing the cards.

Being therefore certain when you deal, that the cards marked 1, 2, 9, 13, 14, and 21 will always be in the adversary's hand, and those marked 4, 11, 12, 16, 23, and 24, will be in your own hand, you must apply your six numbers to such cards, as with the three of the *rentrée*, (which you may choose as you please) will always make a great hand, and superior to the adversary. The great cards which you are forced to leave, you must distribute among
the

the variable cards, in such manner that they can have no remarkable effect, when dealt either way.

This method we have observed in the following example, which we here give for the satisfaction of those who would compose these sorts of games themselves. To the numbers 4, 11, 12, 16, 23, and 24, annex a fixiem major in hearts, which joined to the three tens of the rentrée are sufficient to make a repique, youngest hand. But as you must prevent the elder hand from defeating your point, by having seven cards in any of the other suits, you are so to dispose some part of each suit, by the column of variable cards, that he may never have, whether the cards are dealt by twos or threes, any large sequence*: as you will

* If you cannot effect this by the cards that are to be dealt the adversary, you must so dispose his rentrée, that he may lay out his game, as in the thirty-eighth Recreation.

fee by the following disposition of the cards.

1 King		17 Ace clubs
2 Ace	} diamonds	18 Seven
3 Nine		19 King
4 Ace hearts		20 Ace
5 Queen spades		21 Knave diamonds
6 Eight diamonds		22 Eight clubs
7 Queen clubs		23 Ten
8 Eight spades		24 Queen
9 King clubs		25 Knave
10 Seven		26 Nine
11 King	} hearts	27 Knave clubs
12 Nine		28 Eight hearts
13 Queen	} diamonds	29 Nine clubs
14 Seven		30 Ten diamonds
15 Seven clubs		31 Ten spades
16 Knave hearts		32 Ten clubs

By this arrangement of the cards you will be sure to succeed, whether you deal the cards by twos or threes: even though the adversary, thinking to frustrate your intention, should leave three cards.

Remark:

Remark: there is no danger that any of these recreations at piquet should be applied to a bad purpose, for after the cards have been once shuffled by both players, it will be impossible to succeed in any one of them. There are, however, tricks to be played at this, as at all other games, with the cards; such as changing the whole pack, or some particular cards, or taking in part, or all the discard, or making the pass, that is, bringing part of the cards at bottom to the top, as will be more fully explained in the fourth vol. all of which many persons can perform so dextrously, that it is impossible for the eye to discover them. We say nothing of the practice of marking the cards, for of that almost every one's experience will afford sufficient proof. To aggravate the misfortune, it is indubitably certain, that many persons who are strictly honest in all other respects, are dishonest at cards; and that no rank or condition of men, no, nor woman neither, is entirely free from this vice.

They who make a trade of dexterity frequently exhibit other recreations with the cards; but as those have no relation to numbers, they will be found among the miscellaneous articles in the Appendix to the last volume.

R E C R E A T I O N XLIII.

Several different cards being shown to different persons, that each of them may fix on one of those cards, to name that on which each person fixed.

THERE must be as many different cards shown to each person, as there are persons to choose; therefore, suppose there are three persons, then to each of them you must show three cards, and telling the first person to retain one in his memory, you lay those three cards down, and show three others to the second person, and so to the third. You then take up the first person's cards, and lay them down, one by one, separately, with their
faces

faces upwards. You next place the second person's card over the first, and in like manner the third person's card over the second's; so that in each parcel there will be one card belonging to each person. You then ask each of them in which parcel his card is, and when you know that, you immediately know which card it is; for the first person's card will always be the first, the second person's the second, and the third person's the third, in that parcel where they each say his card is.

This Recreation may be performed with a single person, by letting him fix on three, four, or more cards. In this case you must show him as many parcels as he is to choose cards, and every parcel must consist of that number, out of which he must fix on one; and you then proceed as before, he telling you the parcel that contains each of his cards.

R E C R E A T I O N XLIV.

To name the rank of the card that a person has drawn from a piquet pack.

BY the rank of the card we mean whether it be ace, king, queen, &c. You are therefore first to fix a certain number to each card, thus, you call the king 4, the queen 3, the knave 2, the ace 1, and the others according to the number of their pips.

You then shuffle the cards, and let the person draw any one of them: then turning up the remaining cards, you add the number of the first to that of the second, that to the third, and so on, till it amount to ten, which you then reject and begin again; or if it be more, you reject the ten, and carry the remainder to the next card; and so continue till you come to the last card; and to the last amount you must add 4, and subtract that sum from 10 if it be less

lefs, or from 20 if it be more than 10, and the remainder will be the number of the card that was drawn: as for example, if the remainder be 2, the card drawn was a knave; if 3, a queen, &c.

RECREATION XLV.

To tell the amount of the numbers of two cards that a person has drawn from a common pack of cards.*

THE small cards here tell, as before, according to the number of their pips, but each pictured card tells for 10. Let the person add as many more cards to each of those he has drawn, as will make each of their numbers 25. Then take the remaining cards in your hand, and seeming to search for some card among them, tell them over to yourself, and their

* This Recreation may be made with two persons, by letting each of them draw, and adding the numbers together.

number will be the amount of the two cards drawn. An example will make this plain. Suppose the person has drawn a 10 and a 7, then he must add 15 cards to the first, to make the number 25, and 18 cards to the last, for the same reason : now 15 and 18 make 33, and the two cards themselves make 35, which deducted from 52 leaves 17, which must be the number of the remaining cards, and also of the two cards drawn.

This Recreation may be performed without your touching the cards, thus : let the person who has drawn the two cards deduct the numbers of each of them from 26, which is half the number of the pack, and after adding the remainders together, let him tell you the amount, which you privately deduct from 52, the number of all the cards, and the remainder will be the amount of the two cards. For example, suppose the two cards to be, as before, 10 and 7 ; then the person deduct-
ing

ing 10 from 26 there remains 16; and deducting 7 from 26 there remains 19; those two remainders added together will make 35, which you subtract from 52, and there must remain 17, for the amount of the two cards, as before.

As the number 26 may be thought to lead to a discovery of the principle on which the Recreation is founded, it being manifestly the half of the pack, to render it more mysterious you may take any other number less than 26, but greater than 10, as for example 24, and let the party subtract the number of each of his cards from that; therefore, supposing the numbers to be as before 10 and 7, the remainders will be 14 and 17, which make 31, to which you must add 4, for the double of the 2 you took from 26, and the amount will be 35, which is to be deducted from 52, as before. By this alteration the performance will not only be rendered more abstruse

struse, but also more diversified, as you may change the number, from which those of the two cards are to be deducted, every time you repeat the experiment.

This Recreation may be performed, equally well, with a pack of piquet cards, and then the numbers of the two cards must be deducted from 16, which is the half of the pack; or if you chuse to make it more mysterious, from any other number less than 16 and more than 10; afterwards adding, as in the last case, the double of what that number wants to make it 16.

RECREATION XLVI.

To tell the amount of the numbers of any three cards that a person shall draw from the pack.*

AFTER the party has drawn his three cards, you are to draw one yourself, and lay it aside; for it is necessary that the number of the remaining cards be divisible by 3, which they will not be, in a pack of 52 cards, if only 3 be drawn. The card you draw you may call the confederate, and pretend it is by the aid of that card you discover the amount of the others. Then tell the party to add as many more to each of his cards, as will make its number 16, which is the third part of the remaining 48 cards; therefore, suppose he has drawn a 10, a 7, and a 6:

* This Recreations may also be performed with three persons, but much more readily with one, as the separate additions and subtractions will be very like to occasion confusion.

then

then to the first he must add 6 cards, to the second 9, and to the third 10, which together make 25, and the 4 cards drawn being added to them make 29. You then take the remaining cards, and telling them over, as in the last Recreation, you find their number to be 23, which must be the amount of the three cards the person drew.

You may perform this Recreation likewise without touching the cards, as thus: after the party has drawn his three cards, and you have drawn one, let him deduct the number of each of the cards he has drawn from 17, which is one-third of the pack, after you have drawn your card: and let him tell you the amount of the several remainders, to which you privately add one for the card you drew, and deducting that amount from 52, the whole number of cards, the remainder will be the amount of the three cards drawn. For example, suppose the three cards to be

be 10, 7, and 6, as before; then each of those numbers being subtracted from 17, the remainders will be respectively 7, 10, and 11, which, added together, make 28, to which the single card you drew being added makes 29, and that number deducted from 52 leaves 23, which is the amount of the three cards the party drew.

There is little reason to imagine any one will discover why you here make choice of the number 17; but if you are desirous of rendering the Recreation still more abstruse, and at the same time susceptible of greater variety, you may fix on any other number less than 17, but more than 10; and afterwards add to the amount of the remainders the double of what that number is less than 17; in the same manner as in the last Recreation.

This Recreation also may be performed with a pack of piquet cards; but then you must draw, or, what will answer the

the same purpose, deduct 2, in your own mind, from the whole number 32, that the remainder may be divisible by 3; and let him deduct the number of each of his cards from that sum, which is 10, and add the remainders together, as before; thus, if his three cards be 10, 7, and 6, he is to deduct each of them from 10, which is the third part of 30; therefore the remainders will be 0, 3, and 4, which, added together, make 7, and that added to the 2 you deducted from the whole number, makes 9, which taken from 32, leaves 23, and that must be the amount of his three cards.

Among the different purposes to which the doctrine of combinations may be applied, those of writing in cypher, and decyphering, hold a principal place, as will appear by the following Recreations.

DIFFERENT METHODS OF
WRITING IN CYPHER.

The Lacedæmonians are said to be the inventors of cyphers, or at least they were not, to our knowledge, used by any people before them. Their method was by a wooden cylinder or roller, called a Scytala Laconia, round which they rolled a thin parchment, and wrote their dispatches. It was then taken off and sent to the confederate, who had another roller, exactly of the same size, round which he wrapped the parchment, and read its contents.

RECREATION LXVII.

To communicate intelligence by a pack of piquet cards.

THE parties must previously agree in what manner the cards shall be first placed, and then how they shall be shuffled. Thus, suppose the cards are to be first placed in the order as hereafter follows,
and

and then shuffled by taking off 3 from the top, putting the next 2 over them, and the following 3 under them*, and so alternately. Therefore the party who sends the cypher first writes the contents of it on a separate paper, and then copies the first 32 letters on the cards, by writing one letter on every card; he then shuffles them in the manner described, and writes the second 32 letters: he shuffles them a second time and writes the third 32 letters, and so of the rest. An example will make this plain. Suppose the letter to be as follows:

I am in full march to relieve you; within three days I shall be with you. If the enemy in the mean time should make an assault, remember what you owe to your country, to your family and yourself. Live with honour or die with glory.

* By shuffling the cards in this manner, there will remain only 2 to put under at last.

Order

Order of the cards
before the 1st shuffle.

Ace spades	<i>i a d u y i</i>
Ten diamonds	<i>a l e u l</i>
Eight hearts	<i>m l m o i u</i>
King spades	<i>i s u m l</i>
Nine clubs	<i>n h l e o</i>
Seven diamonds	<i>f b m r i</i>
Nine diamonds	<i>u e a c t n</i>
Ace clubs	<i>l w k r y i</i>
Knave hearts	<i>l s e e a e</i>
Seven spades	<i>m i a r m w</i>
Ten clubs	<i>a' i t h e r</i>
Ten hearts	<i>r r h o f</i>
Queen spades	<i>c h e e i</i>
Eight diamonds	<i>h a h y w</i>
Eight clubs	<i>t y o o o l</i>
Seven hearts	<i>o y a o h o</i>
Queen clubs	<i>r o n u y h</i>
Nine spades	<i>e u i y f y</i>
King hearts	<i>l e t e u o</i>
Queen diamonds	<i>e d s o e</i>
Eight spades	<i>i i n w s o</i>
Knave clubs	<i>v f a n t g</i>

Seven clubs	<i>e t s l y</i>
Ace hearts	<i>y r e b r</i>
Nine hearts	<i>o l n w o t</i>
Ace diamonds	<i>u h s t & d</i>
Knave spades	<i>w l m a l</i>
Ten spades	<i>i e y t r r</i>
King diamonds	<i>t t i b u r</i>
Queen hearts	<i>h h m m u</i>
King clubs	<i>i n a t h</i>
Knave diamonds	<i>n e u r o</i>

The person that receives these cards first places them in the order agreed on, and transcribes the first letter on every card. He then shuffles them, according to order, and transcribes the second letter on each card. He shuffles them a second time and transcribes the third letters; and so of the rest.

If the cards were to be shuffled the second time by threes and fours, the third time by twos and fours. &c. it would make
the

the cypher still more difficult to discover: though as all cyphers depend on the combination of letterss there are scarce any that may not be decyphered with time and pains; as we shall show farther on. Those cyphers are the best, that are by their nature most free from suspicion of being cyphers; as for example, if the letters were here wrote with one of the sympathetic inks, described in the fourth volume of this work, the cards might then pass for a common pack.

RECREATION XLVIII.

The mystical dial.

ON a piece of square pasteboard ABCD (Plate II.) draw the circle EFGH, and divide it into twenty-six equal parts, in each of which must be wrote one of the letters of the alphabet.

On the inside of this there must be another circle of pasteboard, ILMN, move-

able round the center O, and the extremity of this must be divided into the same number of equal parts as the other. On this also must be wrote the letters of the alphabet, which, however, need not be disposed in the same order. The person with whom you correspond must have a similar dial, and at the beginning of your letter you must put any two letters that answer to each other when you have fixed the dial.

Example.

Suppose you would write as follows:

If you will come over to us you shall have a pension, and you may still make a sham opposition.

You begin with the letters *Ma*, which show how the dial is fixed; then for *If you*, you write *un juc*, and so for the rest, as you will see at the bottom of the plate.

The same intention may be answered by a ruler, the upper part of which is fixed
and

and the lower part made to slide: but in this case the upper part must contain two alphabets in succession, that some letter of that part may constantly correspond to one in the lower part. The divisions standing directly over each other in a straight line will be much more obvious than in the circumference of a circle. Or two straight pieces of pasteboard regularly divided, the one containing a single and the other a double alphabet, would answer exactly the same purpose. In this case a blank space may be left at each end of the single alphabet, and one or two weights being placed on both the pieces will keep them steady.

R E C R E A T I O N XLIX.

The corresponding spaces.

TAKE two pieces of pasteboard or stiff paper, through which you must cut long squares, at different distances, as you will see in the following example. One of these pieces you keep yourself, and the

other you give to your correspondent. When you would send him any secret intelligence, you lay the pasteboard upon a paper of the same size, and in the spaces cut out, you write what you would have understood by him only, and then fill up the intermediate spaces with somewhat that makes with those words a different sense.

I shall be, much obliged to you, as reading alone engages my attention at present, if you will lend me any one of the eight volumes of the Spectator. I hope you will excuse this freedom, but for a winter's evening I don't know a better entertainment. If I fail to return it soon, never trust me for the time to come.

A paper of this sort may be placed four different ways, either by putting the bottom at top, or by turning it over, and by those means the superfluous words may be
the

the more easily adapted to the sense of the others.

This is a very eligible cypher, as it is free from suspicion, but it will do only for short messages: for if the spaces be frequent it will be very difficult to make the concealed and obvious meanings agree together; and if the sense be not clear, the writing will be liable to suspicion.

RECREATION L.

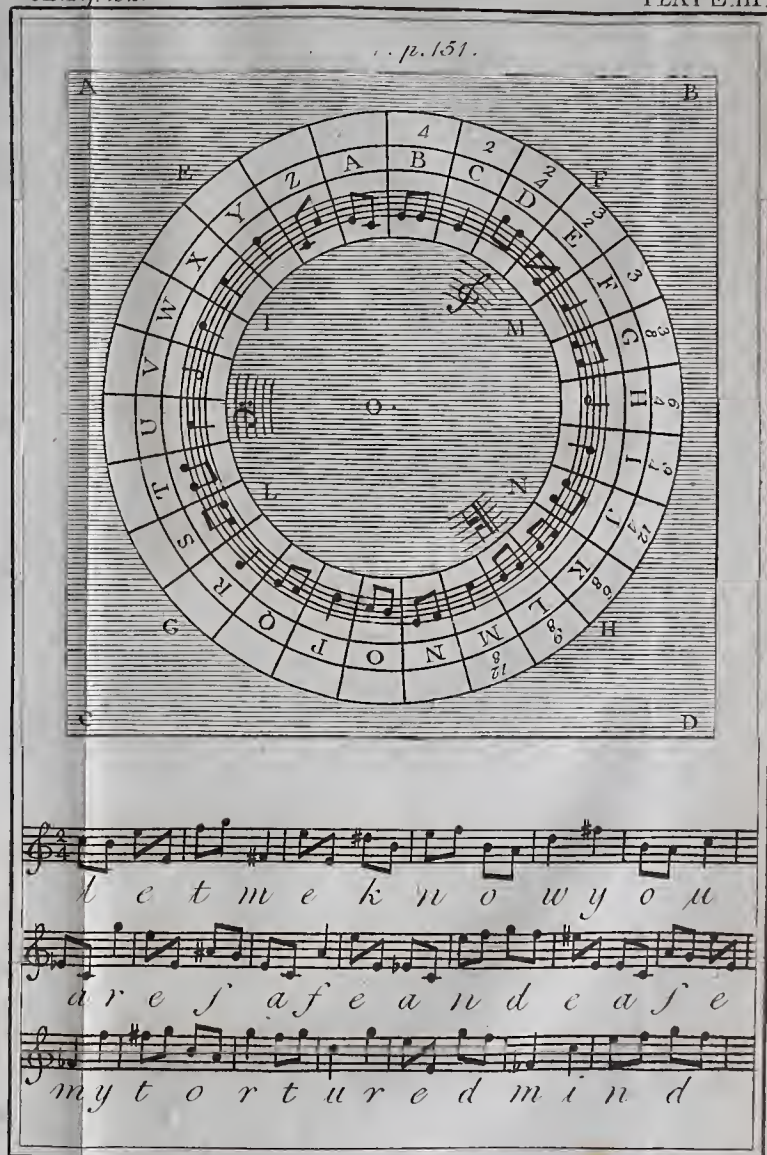
The musical cypher.

THE construction of this cypher, is similar to that of the forty-eighth Recreation. The circle EFGH (Pl. III.) is to be divided into twenty-six equal parts, in each part there must be wrote one of the letters of the alphabet: and on the interior circle ILMN, moveable round the center O, there is to be the same number of divisions: the circumference of the inner circle must be ruled in the manner of

a music paper, and in each division there is to be placed a note, different either in figure or position. - Lastly, within the musical lines place the three keys, and on the outer circle, the figures that are commonly used to denote the time.

Then provide yourself with a ruled paper, and place one of the keys, as suppose that of *ge re sol*, against the time two-fourths at the beginning of the paper, which will inform your correspondent how to fix his circle. You then copy the notes that answer to the several letters of the words you intend to write, in the manner expressed at the bottom of the plate.

A cypher of this sort may be made more difficult to discover by frequently changing the key, and that will not in the least embarrass the reader. You may likewise add the mark * or \square to the note that begins a word, which will make it more easy to read, and at the same time give the



the music a more natural aspect. This cypher is preferable to that of the 48th Recreation, as it may be enclosed in a letter about common affairs, and pass unsuspected: unless it should fall into the hands of any one who understands composition, for he would very likely surmise, from the odd disposition of the notes, “that more is meant than meets the ear.”

OF DECYPHERING.

The rules of decyphering are different in different languages: by observing the following, you will soon make out any common cypher wrote in English.

1. Observe the letters or characters that most frequently occur, and set them down for the fix vowels, including *y*; and of these the most frequent will generally be *e*, and the least frequent *u*.

2. The vowels that most frequently come together are *e a* and *o u*.

3. The

3. The consonant most common at the ends of words is *s*, and the next frequent *r* and *t*.

4. When two similar characters come together, they are most likely to be the consonants *f*, *l*, or *s*, or the vowels *e* or *o*.

5. The letter that precedes or follows two similar characters is either a vowel, or *l*, *m*, *n*, or *r*.

6. In decyphering, begin with the words that consist of a single letter, which will be either *a*, *I*, *o*, or *&*.

7. Then take the words of two letters, one of which will be a vowel. Of these words the most frequent are, *an*, *to*, *be*, *by*, *of*, *on*, *or*, *no*, *so*, *as*, *at*, *if*, *in*, *is*, *it*, *he*, *me*, *my*, *us*, *we*, *am*.

8. In words of three letters there are most commonly two consonants. Of these words the most frequent are, *the*, *and*, *not*, *but*, *yet*, *for*, *tho'*, *how*, *why*, *all you*, *she*, *his*, *her*, *our*, *who*, *may*, *can*, *did*, *was*, *are*, *has*, *had*, *let*, *one*, *two*, *six*, *ten*, &c*.

* Some of these, or those of two letters, will be found in every sentence.

9. The

9. The most common words of four letters are, *this, that, then, thus, with, when, from, here, some, most, none, they, them, whom, mine, your, self, must, will, have, been, were, four, five, nine, &c.*

10. The most usual words of five letters are, *there, these, those, which, were, while, since, their, shall, might, could, would, ought, three, seven, eight, &c.*

11. Words of two or more syllables frequently begin with double consonants, or with a preposition; that is a vowel joined with one or two consonants. The most common double consonants are, *bl, br, dr, fl, fr, gl, gr, ph, pl, pr, sh, sp, st, th, tr, wh, wr, &c.* and the most common prepositions are, *com, con, de, dis, ex, im, in, int, mis, par, pre, pro, re, sub, sup, un, &c.*

12. The double consonants most frequent at the end of long words are, *ck, ld, lf, mn, nd, ng, rl, rm, rn, rp, rt, sm, st, xt, &c.* and the most common terminations are, *ed, en, et, es, er, ing, ly, son, sion,*

fion, tion, able, ence, ent, ment, full, less, nefs, &c.

We shall here give an example of a cypher wrote in arbitrary characters, as is commonly practised.

ΕΛΧΟΟ ΕΛ+ΙΟ Λ+ΓΕΛΔ
 ΣΓΩ. Γ+Ε +ΓΟ ΙΟΓΟ +
 ΛΧΕΟΙ ΣΓΩ. ΘΟΧΠΟΩΟ+ΕΔ
 ∇+Ε ΕΟΙΙ. ΕΣΙΠ +Π
 ΘΧΕΩΟΓΛΟ ◇. ΛΣΕΕΟ+Γ
 Γ+ ΕΧΣΕΟ+Χ ΕΕ ΕΔ
 ΕΓΩΟΠΠΟΧΟΓΛΟ ◇
 ΓΟΤΙΟΛΕ ΟΕΛΟΧ ΠΟΓΩ.
 Δ+ΛΟ ΛΟΣΓΔ Γ+ ΔΟΓΩ.
 ΛΟ Σ ΙΟΕΕΟΧ ΔΛ+ΧΕΙ∇
 ◇ ΙΟΕ ΛΟ ΔΟΟ ΕΛΣΕ ΕΕ
 Ε+ΛΟΔ ΠΧ+Λ ΕΛΟ ΛΟΣΧΕ
 +Χ ΓΟΝΟΧ ΩΣΧΟ Ε+ ΔΟΟ
 Λ∇ ΠΣΛΟ Λ+ΧΟ.

The foregoing will be easily decyphered by observing the rules; but when the characters are all placed close together, as in the following example, and as they always should be, the decyphering is much more difficult.

UENODNCEUΓUUEXEST
 OSΔUCX∇ΛXΓ∇∇STOΔO
 NXO□OCN∇∇ΓOOXE+∇X
 +XΔSOXUEXΓΓUXSΔUE
 XΘNUΓOX∇.+XLT◇Θ□TG
 ∇USUEXESTOΓ◇□ΘSEX
 CX∇∇LTGXLTGX□USOXΓ
 ΓN◇NSTO∇N+XO□NPO□
 NX+OΓΛX∇NUENONOUUE
 XONDCEUUEΓUXNUEXOE
 ΓΘXOTOSOT◇□SXOTOL
 TNUX.

To decypher a writing of this sort, you must first look for those characters that most frequently occur, and set them down for the vowels, as before. Then observe the similar characters that come together; but you must remember that two such characters may here belong to two words. You are next to remark the combinations of two or three characters that are most frequent, which will be some of the words in the seventh and eighth of the foregoing rules; and by observing the other rules, you will infallibly discover, with time and attention, any cypher wrote on these principles*.

* When the words are wrote all close together, if the key to the cypher were to be changed every word, according to a regular method agreed on between the parties, as might be done by either of the methods mentioned in the 48th Recreation, with very little additional trouble, the writing would be then extremely difficult to decypher. The longer any letter wrote in cypher is, the more easy it is to decypher, as then the repetitions of the characters and combinations are the more frequent.

The

The following are the contents of the two foregoing cyphers; in which we have inverted the order of the words and letters, that they who are desirous of trying their talent at decyphering, may not, inadvertently, read the explanation before the cypher.

enil eno ton dna shtnom elohw eerht,
 suoidifrep dna leurc o. noituac & ecnedurp
 fo klat lliw uoy: on, rotiaart, tcelgen
 & ecnereffidni si ti. yltrohs rettél a em
 dnes ot snaem emos dnif rehtie, traeh eht
 morf semoc ti taht ees em tel &, erom
 ecaf ym ees ot erad reven ro.

evlewt fo ruoh eht ta thgin siht, ledatic
 eht fo etag eht erofeb elbmessa lliw sdneirf
 ruo lla. ruoh eht ot lautcnupeb: deraperp
 llew emoc dna, ytrebil ruoy niager ot,
 ylevarb eid ro. thgin eht si siht, su sekam
 rehtie taht, etiup su seodnu ro.

The

The method of corresponding by figures being nearly related to that of cyphers, we shall here give two instances of the manner in which it may be performed.

RECREATION LI.

Visual Correspondence.

PROVIDE a circle of wood ABCD (Plate IV. Fig. 1.) of about four feet in diameter, and divide its circumference, which will be about 12 feet, into 25 equal parts. In one of these spaces cut an open square, and through each of the others cut one of the 25 letters of the alphabet. (*I* serving for *J*.) Over the spaces that are cut out paste a thin oiled paper.

On the top of a pole P (Fig. 2.) fixed to the ground or floor, place a frame of wood EF, in which there is to be an opening of the same size with one of the divisions on the wheel. On the outside of this opening

ing let there be a door, by which it may be occasionally closed. To the pole let the wheel be fixed, at its center G, round which it must turn, and be placed at such a height that the letters on its circumference may answer to the hole in the frame. Behind that part of the wheel which is opposite the board, let there be fixed, on a stand, a strong light.

When you would communicate your intelligence, open the door on the outside of the frame; then put that division of the wheel in which the square is cut, against the opening, and place the light behind it; that serves for a signal to your correspondent, which he answers by putting his wheel in the same position*. What you intend to communicate being wrote on a paper and placed before you in a

* Where there is a frequent correspondence required, certain hours of the day should be fixed for observing the signal.

proper position, you turn the wheel round, till that division which contains the first letter of the first word come before the opening, and keep it there while you tell 4; you then turn the wheel, either backward or forward*, to the second letter and keep that before the opening the same time; and so of all the letters of that word; and between every word you place the vacant division before the opening, while you, in like manner, tell 4. When you have finished the whole of your intelligence, you shut the door of the frame, or withdraw the light.

If your correspondent be far off, as suppose two or three miles, or farther, you must be each provided with a telescope, of a size adapted to the distance between you.

* There may be placed handles on different parts of the wheel as at *a*, *b*, *c*, *d*, by which it will be the more readily turned about.

Your

Your apparatus should be placed some way within the room, that it may not be obvious to passengers. It is evident, from the construction of this instrument, that it is full as well adapted for a correspondence by night as by day.

A machine of this sort may be constructed at a trifling expence, and will be found highly useful in many instances, as where two persons live on the opposite sides of a large river, or in a country where the roads are for a great part of the year impassable, &c. If you are fearful any person, beside your correspondent, should know what passes, instead of letters, you may use 24 characters, like those we have given in the last example of cyphers.

This invention may also be applied to public use, as to convey intelligence to the garrison of a town besieged; or where great dispatch is required; and in that

case several machines may be placed at different distances, that may convey the intelligence to each other ; and here the wheel may be of a much larger dimension. There is one circumstance, however, that will render this contrivance entirely useless, and that is a thick mist or fog ; for in that case, let the light be as strong, and the letters as large as they may, it will be impossible to discern them at any considerable distance. How to maintain a correspondence in that situation, will be shown in the next Recreation.

R E C R E A T I O N LII.

Auricular Correspondence.

ON the top of a house, or any other building, fix two bells A and B, (Pl. IV. Fig. 3.) by the iron rod CD, that passes thro' their handles, from which there must hang two ropes that go to the room beneath. The weight

weight of the handles should be nearly equal to that of the bells, so that a small additional force applied to the ropes may draw them up. One of the bells must be much larger than the other, that there may be no difficulty in distinguishing their sounds.

The letters of the alphabet are to be expressed by pulling of these bells, according to the following order; in which you are to observe, that the small figures denote the number of pulls of the lesser, and the numeral letters, those of the greater bell.

A 1	G 1 I	N 1 III	T II 1
B 2	H 2 I	O 2 III	V II 2
C 3	I 3 I	P 3 III	U II 3
D I	K 1 II	Q I 1	W III 1
E II	L 2 II	R I 2	X III 2
F III	M 3 II	S I 3	Y III 3
			Z IIII

M 3

After

After each letter you must stop while you tell 4, and at the end of each word you may, for greater distinction, pull both bells twice together.

The above combinations may be continued to what number you please; so as to take in the most common words, such as *and, the, you, he, she, they, them, this, that, may, can, do, &c.*

Fig. 2. p. 160.

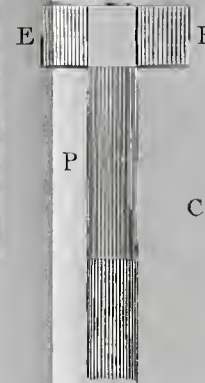


Fig. 1. p. 160.

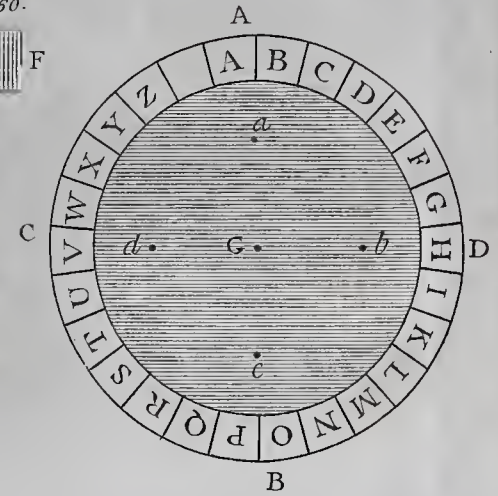
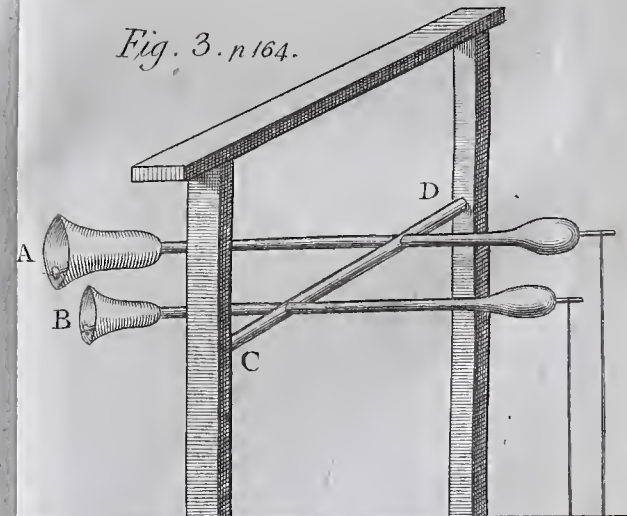


Fig. 3. p. 164.







M E C H A N I C S.



M E C H A N I C S.

D E F I N I T I O N S.

1. **M**ECHANICS is that science which explains the properties of moving bodies, and of those machines from which they frequently receive their motion.

2. Gravity is that power by which every body naturally descends toward the center of the earth.

3. The center of gravity, in a single body, is that point round which the several parts of the body, in every situation, exactly balance each other, and consequently if that point be suspended the body will remain at rest.

4. The center of gravity, in two or more bodies, is that point between them, from which the distance of each is in proportion to the quantity of matter it contains. The less the matter the greater the distance.

5. The

5. The *Vis Inertiæ*, or Inert Force, is that property in bodies, by which they resist the power that endeavours to put them in motion.

6. The density of bodies is the quantity of matter they contain, compared with their magnitude or dimensions.

7. Elasticity is that property in bodies by which, when their parts are forced out of their natural state, they return to it again; and by which two moving bodies, after striking, recoil from each other.

8. Power, in mechanics, is the force by which any body is put in motion.

9. Weight, is the body to be moved.

10. Motion, is either simple or compound: simple motion is that which proceeds from one power only; and compound motion is that which proceeds from two or more powers, either at the same time or in succession.

11. The center of motion is that point round which one or more bodies move.

12. Ve-

12. Velocity of motion, is the space passed over by a body in a given time.

13. Accelerated motion, is that which continually increafes, and retarded motion is that which continually decreafes.

14. The quantity of motion, or momentum of a moving body, arifes from its velocity multiplied into the quantity of matter it contains.

15. There are fix primary mechanic instruments, commonly called mechanic powers, which are (1.) the lever*, (2.) the balance, (3.) the pulley, (4.) the wheel and axis, (5.) the fcrew†, and (6.) the wedge: to which is fometimes added the inclined

* Levers are faid to be of the firft, fecond, or third fort, according to the fituation of the fulcrum F, as in Pl. V. Fig. 1, 2, 3; to which is added the bended lever, Fig. 4.

† There are feveral forts of fcrews ufed in machines, of which thofe of Fig. 8, and 9 Pl. V. are moft common. In Fig. 8, the part AB is called the male fcrew, and CD the nut, or female fcrew. The part AB (Fig. 9.) which is turned by the wheel CD, is called an endlefs fcrew, becaufe, while the wheel goes, it turns inceffantly.

plane:

plane: and of some or all of these every compound machine is composed. See Plate V.

16. A pendulum is any body suspended from a point, from which it oscillates or vibrates, as from a center; but is generally understood to be a ball suspended at the end of a string or wire.

17. That resistance which arises from the rubbing of the parts of a machine against each other, is called their friction.

A P H O R I S M S.

1. Every body, whether at rest or in motion, will constantly continue in its present state, unless compelled to alter it by some external power.

2. All motion, whether changed or generated, is in proportion to the force impressed, and is made in the direction that force acts.

3. Action and re-action, that is, the impulses of two bodies on each other, are
always

always equal, and in contrary directions.

4. In bodies not elastic, if one in motion strike against another at rest, they will both move in the direction of the first moving body; and the quantity of motion in both bodies will be the same as it was in the first before the stroke.

5. If one such body in motion, strike against another moving in the same direction, but with less velocity, they will both continue in that direction, and the quantity of motion in both bodies will continue the same.

6. When two such bodies, with equal quantities of motion, and moving in opposite directions, strike against each other, their whole motion will be destroyed, and they will remain at rest.

7. If two such bodies, with different quantities of motion, and moving in opposite directions, strike against each other, they will continue to move in the direction of that body which had the greatest
momen-

momentum, and the quantity of motion in both bodies, after the stroke, will be equal to the difference of their motions before it.

8. The force of action in elastic bodies is twice as great as that of non-elastic bodies; for the former strike each other not only by impulse, but by repulse; recoiling from each other after the stroke*.

9. The inert force of every body is in proportion to its density.

10. All bodies near the surface of the earth descend equal spaces in equal times†.

11. The velocity of falling bodies, in unresisting mediums, is 16 feet the first

* In these aphorisms bodies are supposed to be perfectly elastic or non-elastic: in all other bodies they will hold true only in proportion to the degrees of their elasticity.

† This must be understood of such as are called heavy bodies; for in those that are light the resistance of the air makes a considerable difference. A bullet and a feather fall with very different velocities in the air, though in the exhausted receiver they descend together.

second,

second, nearly, and becomes continually accelerated in a regular progression.

12. In every pendulum all its vibrations in small arches, or parts of circles, are made in the same time.

13. The times of vibrations in different pendulums, are as the square roots of their length*: therefore a pendulum of four feet will vibrate twice while one of 16 feet vibrates once.

14. The length of a pendulum that vibrates every second, will be 39 inches, nearly†, and one that vibrates twice in a second will be $9\frac{4}{5}$ inches.

15. Any body, in the form of a rod or staff, that is every where of equal density, as an iron rod, and that is one third longer than a pendulum, will vibrate in the same time as that pendulum.

16. In the lever, where the power P

* See page 2. definition 2.

† A pendulum of this sort is therefore a regular measure of time, and may be of use on many occasions.

Pl. V. Fig. 1.) and weight W are to each other reciprocally as their distances from the fulcrum F , they will be in equilibrio*.

17. The balance being a lever of the first kind, where the fulcrum is placed exactly between its two extremities, if two weights E, F , (Pl. V. Fig. 5.) be placed any where, at equal distances from the fulcrum, and the balance remain in equilibrio, those weights must be equal.

18. When a power sustains a weight, by a rope going over a fixed pulley, the weight and power will be equal: but if one end of the rope be fixed, and the pulley be moveable with the weight, then the power will be but half the weight.

19. In a combination of pullies, as A, B, C, D , (Pl. V. Fig. 6.) called a tackle of pullies, the power will be to the weight,

* The lever is to be regarded as the origin of the other powers, seeing they all act in a similar manner, though in different directions,

as 1 to the number of ropes applied to the moveable pullies C D, that is, in this case, as 1 to 4.

20. In the wheel and axis, the power will be to the weight, as the diameter of the axis is to the diameter of the wheel.

21. When there is a combination of wheels and axles, the power will be to the weight, as the diameters of the axles multiplied into each other, is to the diameters of the wheels multiplied into each other.

22. In the screw, the power is to the weight, as the perpendicular distance between any two threads of the screw A B, (Pl. V. Fig. 8.) is to the circumference of the circle described by the power at C or D*.

23. In the wedge, the power is to the weight or resistance, as half the length of the base CE (Fig. 10.) to its height E F.

24. In the inclined plane, the power is

* The screw has the peculiar advantage of sustaining a considerable weight, when once raised, though the power be taken away.

to the weight, as the height of the plane CD (Fig. 11.) is to its length AB.

25. A body acquires the same velocity by rolling down an inclined plane AB (Fig. 11.) as it would by falling through its perpendicular height CD.

26. It is evident from the foregoing aphorisms, that whatever is gained in time is lost in power; and that no machine can of itself give any fresh power, but by diminishing the velocity of the weight, and increasing that of the power, bring them to an equality.

27. When a fly is added to any machine, as to a common jack, it does not increase, but diminish, the strength of the power; its only use being to regulate the motion of the machine, and keep it constantly equal*.

* Though the fly does not in reality add any fresh power, yet by regulating the motion, it will in some cases, as when a man is employed to turn a large wheel, render the operation of the power more easy and efficacious.

28. In

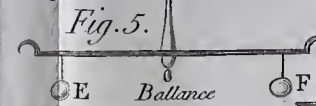
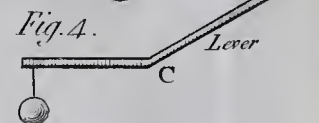
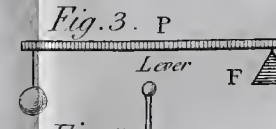
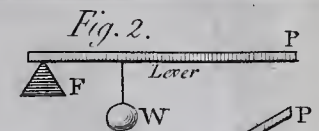
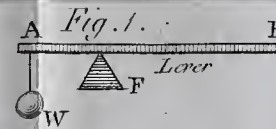
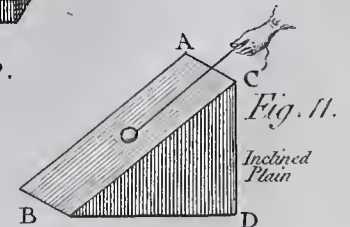
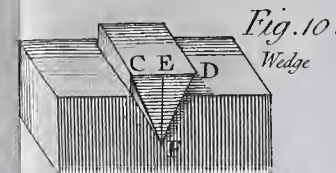
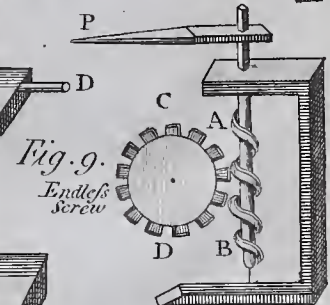
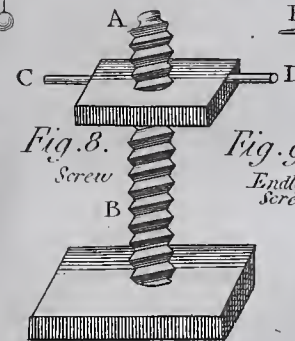
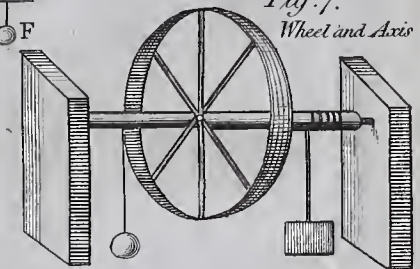
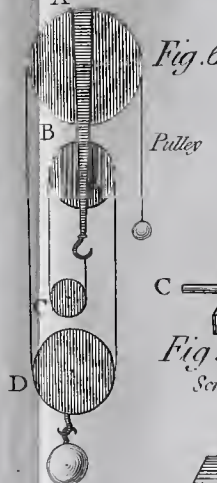


Fig. 7.
Wheel and Axis



28. In every machine, when the weight and power are in equilibrio, the least additional power should put it and keep it in motion; but from the friction of the several parts of the machine, it is found that, on a medium, near one-third of the first power must be added to keep the machine in motion.

29. The friction of a machine does not arise merely from the number of the rubbing parts, but from the weight with which they are charged, multiplied into the velocity of the motion.

30. In all machines, simplicity is their primary excellence, as they are thereby less liable to friction and impediment; the disorder of any one part of a machine frequently obstructing the operation of the whole.

R E C R E A T I O N LIII.

To construct a mechanical dial without wheels, spring, or weight.

THIS dial consists of a tin or copper barrel or cylinder CD, (Plate VI. Fig 1.) which is supported by two strings of catgut that are fastened to the points A and B. This cylinder, for common use, may be about a foot long, and nine inches diameter.

The principal mechanism of this dial is in the internal structure of the cylinder which is represented by Fig. 2. and consists of five divisions*, that are formed by the five pieces *af*, *bg*, *ch*, *di*, and *el*, placed perpendicular to the ends of the cylinder: all these divisions must be precisely equal; and in each of the partitions

*. There are sometimes six or more divisions, and the machine is commonly esteemed the more accurate for having a greater number.

almost close to the circumference of the cylinder, there is to be a small hole, such as is made with a large needle.

In the divisions must be placed a quantity of water, equal to about one-fourth of the content of the cylinder; but the exact proportion can be determined by trial only. This water should be distilled, or at least well filtered, that it may not, by growing foul, impede the motion of the machine; and if there be a due quantity of spirits mixed with the water, it will be thereby prevented from freezing. At one end of the cylinder is a small hole, by which it may at any time be emptied; this hole is to be stopped with wax.

The barrel being brought up to the points A and B, by winding the string round its axis, it would there rest, but the water oozing through the small holes in the upper partitions destroys its equilibrium; and as it slowly and gradually de-

sends, the small points at the end of its axis show the hours, and parts of an hour, according to the number of divisions on the scales E or F.

If this dial go too fast or slow, it may be easily regulated, either by diminishing or increasing the size of the catgut, or the quantity of water in the cylinder.

Machines of this kind are most common in monasteries, and are frequently made by the monks themselves, for their own private use; the purchase of a watch requiring a sum of money which is very rarely possessed by any of that class of men; if they can be called men who disclaim the principal characteristic of manhood.

RECREATION LIV.

A dial to show the hour by gradually descending an inclined plane.

THE external structure of this dial consists of two parallel plates, connected by a hoop AB (Pl. VI. Fig. 3.) which is placed about one-eighth of an inch beneath the circumference of the plates. These plates are indented, to prevent their sliding down the plane. On the front plate are inscribed the 24 hours; and at its center is a small hollow hemisphere g, moving freely on a pin: the lower part of this hemisphere is filled with lead, that keeps the little gentleman who sits upon it, and points with his finger to the hour, constantly in an erect position. The deep shades in the plate represent its concavity, which is about half an inch.

Fig. 4. in the same plate, represents the internal structure of this dial. LETQ
N 4 is

is the circumference of the hoop: f a frame-plate, on which is placed the train of wheels, 1, 2, 3, 4, which are nearly similar to those in another dial, and are, in like manner, governed by a balance and regulator. There is here no spring, nor fusee, their effects being otherwise supplied, as will appear hereafter. The great wheel of the train is placed upon the axis of the movement, at the center, and the other wheels on one side, which would give the machine a movement, for a short time, on a horizontal plane: it is therefore necessary to fix a thin plate of lead, C, on the opposite side, to preserve the equilibrium. The machine will then rest in any position on the horizontal plane HH; but if it be placed on the inclined plane DGD, it will touch it in the point G, but cannot rest there; for the center of gravity at M, acting in the direction MT, and having nothing to support it, must necessarily descend, and carry the body down the plane.

But

But if on the other side such a weight P . be fixed, as shall remove the center of gravity from M to V , in the line LG , which passes through the point G , then it will naturally rest on the inclined plane.

Now if the weight P be not fixed, but suspended at the end of an arm or lever, which is fastened to the center-wheel 1 , moving on the axis of the machine at M , and which communicates, by its teeth, with the other wheels; in that case, if the weight P be just equal to the resistance arising from the friction of the train, the dial will remain at rest, as on a horizontal plane.

But if the weight P be superior to the resistance of the train, it will necessarily put it in motion, and the dial will then gradually descend the inclined plane; while the weight P , its arm PM , and the wheel 1 , constantly preserve the same position

position they were in when the dial began to move,

From what has been said it is easy to conceive that the weight P may have such a determinate gravity as shall act upon the train with any required force, and consequently produce a motion in the machine of any required velocity, such, for example, as shall carry it round once in 24 hours. Therefore, if the diameter of the dial plate be four inches, it will describe the length of its circumference, that is, 12 inches five-tenths, nearly, in the 24 hours. From whence it follows, that this movement may be made to continue any number of days, by a proportional increase of the length of the plane; and if that were infinite, the motion of the dial would be perpetual.

The motion of this dial is easily accelerated or retarded by raising or depressing the inclined plane, by means of the screw

S (Fig.

Fig. 1. p. 180.

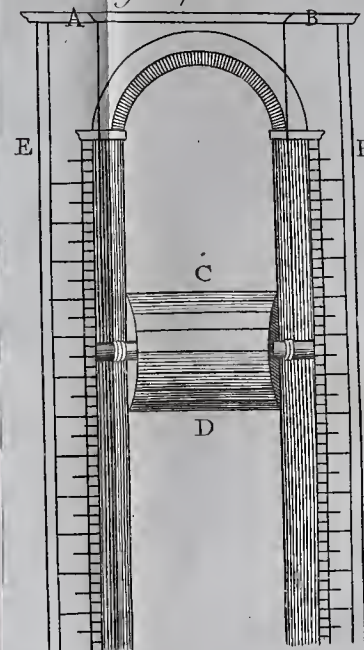


Fig. 2. p. 180.

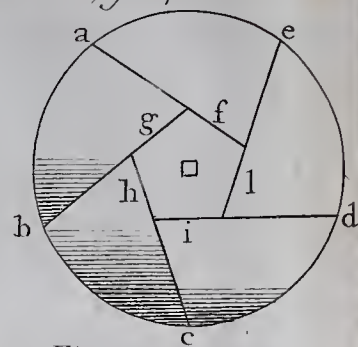


Fig. 4. L. p. 183.

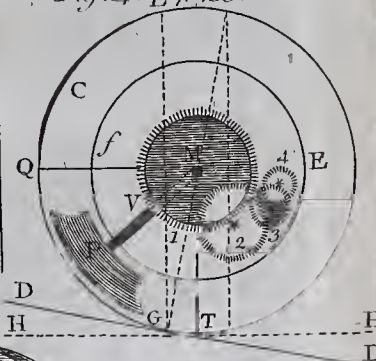
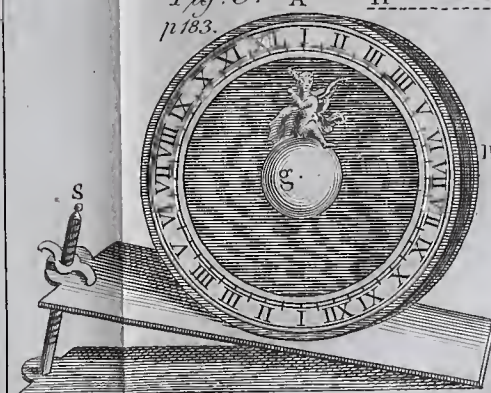


Fig. 3. p. 183.



S (Fig. 3.) The angle to which the plane is first raised is about 10 degrees, that is, the ninth part of a quadrant, or quarter of a circle.

RECREATION LV.

A clock to go perpetually by the influence of the celestial bodies.

THE construction of the movements in this clock is the same with those in common use: it differs from those only in its situation, and the manner in which it is wound up.

This clock is to be placed near a wall, by, or against, which the tide constantly flows. To each of the barrels, round which the string that carries the weight is wound, there must hang a bucket, and into that, when the tide rises to a certain height, the water runs, by means of a pipe fixed in the wall. The bucket then overbalancing the weight, descends, and winds up the clock;

clock; but when it comes to a certain depth, it is taken by a catch fixed in the wall, which, by turning it over, discharges the water. The weights of the clock then descend in the usual manner, and the buckets are drawn up.

Now as this clock is kept in motion by the tide, and as the tide proceeds from the influence of the sun and moon, it necessarily follows, that the motion of the clock proceeds from the same cause; and that as long as the parts of the machine remain, motion will be perpetual.

This, according to the common, acceptance of the term, is certainly a perpetual motion; and so is every mill that is driven by a constant stream; but that is not the sense in which the term was used by the advocates for a perpetual motion in the last century. They meant a machine, which, being once put in motion, should, by its peculiar construction, move perpetually,

tually, without any fresh force impressed. This they attempted by various means; as the attraction of a loadstone, the descent of heavy bodies, the difference of the momentum, in revolving weights, &c. all of which, though ingenious enough, discover a want of due attention to the principles of mechanics. Besides, if a perpetual movement could be effected by either of those means it would be of very little, or no use: for the unavoidable wear of the several parts of the machine, arising from the incessant friction, must necessarily destroy that equality of motion, which alone could render its perpetuity of any consequence.

R E C R E A T I O N LVI.

The Inscrutable lock.

THE difficulty a stranger would find in opening this lock, when in possession of the key, arises partly from the scutcheon that is placed before it, and partly from the peculiar form of the key.

The scutcheon A B (Pl. VII. Fig. 1.) consists of a circular plate of brass or iron, on whose rim are 24 teeth, that take the leaves of the pinion C: this scutcheon may therefore be placed in 24 different positions; in several, or all of which, the key may be inserted, but the lock opened in one of them only: D, is the aperture for the key, and *a, b, c, d*, are four knobs by which it is turned about.

The key A B C D (Fig. 2.) consists of two sets of wards, which are divided into
twelve

twelve parts, as is expressed by the parallel lines in the figure, and which should be made to join so exactly, that when they are pressed together, their divisions may not be visible. At the middle of the key is a screw E, which, when turned in, fastens all the parts together, and when screwed out, sets them at liberty, that they may be turned round the barrel of the key, at the center of each part. When you have locked the door, you turn the scutcheon about by one of the knobs; then unscrewing the wards of the key, you turn part of them half round, that is, you bring some of those parts that were next AB to CD, and then make them fast again, by the screw at the end.

Now if the person, into whose hands this key shall fall, be ignorant of the screw, it will be absolutely impossible for him to open the lock; and if he should know the use of it, the trials he must make before he can have any prospect of success,

cefs, will render the attempt highly abfurd; for there being 12 divifions in the key, it appears by the 18th Recreation of this volume, they may be placed in 479,001,600 different pofitions, and as each of thefe pofitions may be applied to the feveral ways in which the fcutcheon may be placed, it follows, that if the foregoing number be multiplied by 24, the product, which is 11,496,038,400, will be the number of all the trials that can be made: therefore, it is eleven thoufand four hundred and ninety-fix millions, thirty-eight thoufand, three hundred and ninety-nine, to one, at each trial, that he does not open the lock.

For common purpofes a much lefs number may fuffice: fuppofe, for example, there are only feven divifions in the key, the number of trials will be then 120,960. Now fuppofing 60 trials to be made in an hour, it would require 2016 hours to make all thofe trials, that is, to be fure of fucceeding;

ceeding; that is, supposing again, a regular account to be kept of each trial as it is made, for otherwise the same trial might, and naturally would, be made several times.

RECREATION LVII.

So to dispose a hand-mill, to grind corn, &c. that being once put in motion, it shall work incessantly, from morning to night, without the assistance of any animal power.

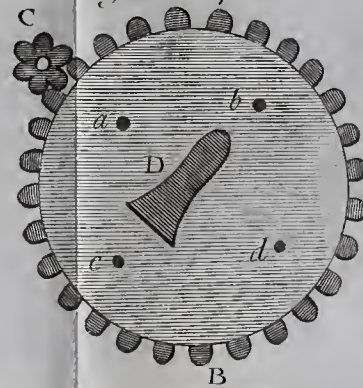
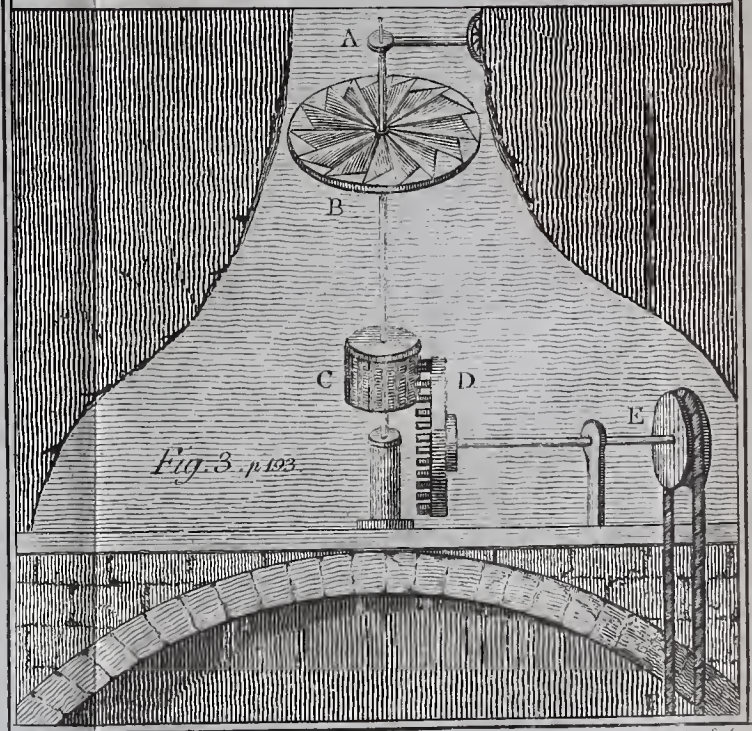
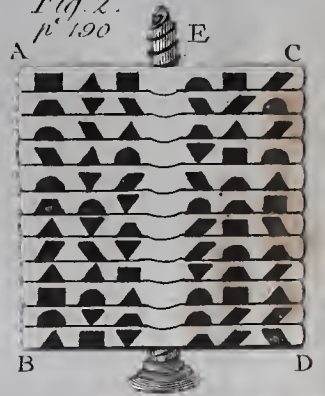
THE form of this mill may be similar to those in common use: its motion is to be maintained by means of a smoke-jack: the use of this sort of jack is common enough; but its construction and manner of acting being clearly understood by few, we shall here describe them.

The horizontal wheel AB (Plate VII. Fig. 3.) is placed in the narrowest part of the chimney that is next the fire: its wings, which are made of tin, are inclin-

ed to the horizon, that is, placed in a sloping direction. To the same axis on which AB turns, is likewise placed the cog-wheel C, that takes the teeth of the perpendicular wheel D. On the same axis with D, is placed the wooden wheel E, round which runs the rope F, on whose lower part is placed the wheel of the spit.

Now, the air, being rarefied by the fire, forces up the chimney, and meeting with the wings of the horizontal wheel in the narrowest port, necessarily turns it round, and at the same time turns the cog-wheel C, which turns D and E, together with the rope, which by its friction against the wheel of the spit, keeps that likewise constantly turning; and its velocity will be always in proportion to its weight, and the strength of the fire.

Therefore, if instead of the iron spit, the handle of the mill be fixed in the center of the lower wooden wheel, it must, in like manner, turn that round: and the
motion

Fig. 1. A p. 190.*Fig. 2. p. 190.*



motion will continue not only while the fire lasts, but a considerable time after; for there will be a continual circulation of the air up the chimney, till that in the room becomes equally cold with the external air.

This machine may in like manner be applied to the reeling of yarn; to the making a hammer strike perpetually on an anvil; and many other domestic purposes.

RECREATION LVIII.

A carriage to go without any other force than what it receives from the passengers.

THIS machine is represented by A B C D, (Pl. VIII. Fig. 1.) It is moved by the footman behind it; and the fore wheels, which act as a rudder, are guided by the person who sits in the carriage*.

* This machine was invented by M. Richard, a physician of Rochelle, and was exhibited at Paris in the last century. It is described by M. Ozanam in his *Recreations Mathematiques*.

Between the hind wheels is placed a box, in which is concealed the machinery that moves the Carriage. AA, Fig. 2. is a small axis, fixed into the box. B is a pulley, over which runs a rope, whose the two ends are fastened to the ends of two leavers or treddles CD, whose other ends are fixed in such manner in the piece E, which is joined to the box, that they can easily move up and down. FF are two flat pieces of iron, that are joined to the treddles, and take the teeth of the two wheels HH, which are fixed on the same axis with the hind wheels of the carriage, I, I.

It is evident that when the footman behind presses down one of the treddles, suppose C, with his foot, he must bring down one of the pieces of iron F, and consequently turn the wheel H that is next to it, and at the same time, by means of the rope that goes over the pulley, he must raise the other treddle D, together with its piece F, which being thrust down, will turn the other wheel H; and so alternately:

Fig. 1. p. 195.

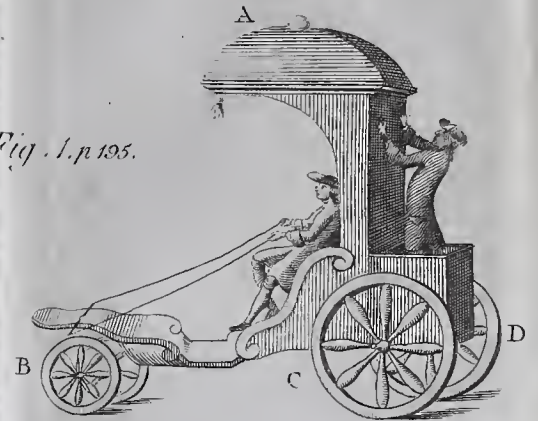
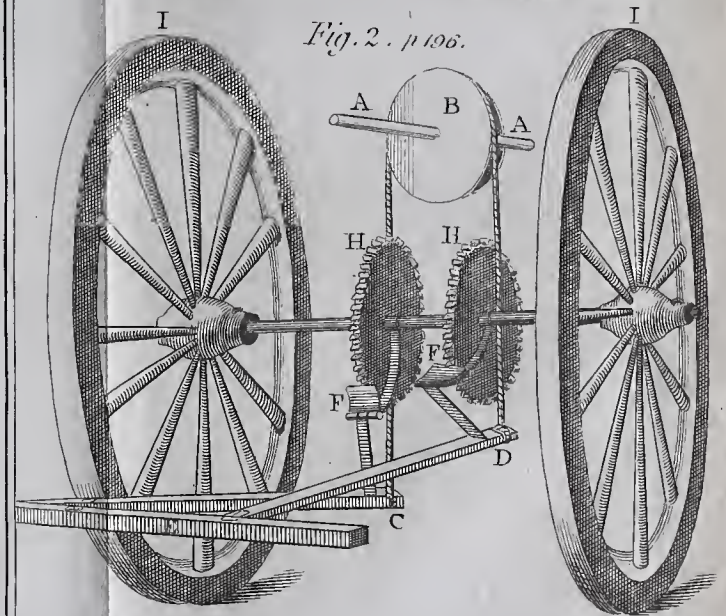


Fig. 2. p. 196.



ly: and as the great wheels are fixed on the same axis, they must necessarily move at the same time.

It is easy to conceive that if the ends of the treddles next E, instead of being placed behind the carriage were turned the opposite way, so as to come under the feet of the person who sits in it, he might move it with equal, or even greater facility, than the footman, as it would then be charged with the weight of one person only.

A machine of this kind will afford a salutary recreation in a garden, or park, or on any plain ground, but in a rough or deep road must be attended with more pain than pleasure.

R E C R E A T I O N LIX.

The catapulta.

THIS engine was in great repute among the ancients, and used by them in throwing darts or spears against their enemies, from whence it had its name. Some of the spears or darts thrown by these engines are said to have been eighteen feet long, and to have been thrown with such velocity as to take fire in their course*.

* It will not be improper to insert here, what is related by writers of the last century concerning the force of darts or arrows. Greaves, in his *Pyromodographia*, says, "Some Turkish bows are of that strength as to pierce a plank six inches thick." He adds, "I speak what I have seen." And Barclay, a writer of sufficient credit, in his *Icon Animorum*, speaking of the Turkish bow, which differed very little in form from the long low bow, anciently in use among us, being drawn by the hand, without the help of the rack that is used to some other bows. He says, "I was an eye witness, how one of these bows, with a little arrow, did pierce through a piece of steel three fingers
" thick."

ABCD, (Pl. IX. Fig. 1.) is the frame that holds the darts or arrows, which may be of different numbers, and placed in different directions. EF, is a large and strong iron spring, which is bent by a rope that goes over the three pullies I, K, L, and is drawn by one or several men; this rope may be fastened to a pin at M. The rope therefore being set at liberty, the spring must strike the darts with great violence, and send them with surprising velocity to a great distance. This instrument differs in some particulars from the description we have of that of the ancients; principally in throwing of several darts at the same time, one only being thrown by their's. A machine of this sort would be of use in those countries where there are frequently large flights of birds, for a great

“thick.” Of facts like these a man may be very well allowed to doubt, or to suppose they were attended with some deception: yet totally to disbelieve them, when related by such witnesses, merely because they are to us impracticable, favours rather of ignorance and temerity than a rational caution.

number of arrows being thus discharged at the same instant, could not fail of doing remarkable execution.

RECREATION LX.

To sail as fast, with a fair wind, by land as by water.

THIS is to be effected by means of a sailing chariot, or boat fixed on four wheels; as AB (Plate IX. Fig. 2.) which is driven before the wind by the sails CD, and guided by the rudder E. In a chariot of this kind the wheels should be farther asunder, and the axle-trees longer, than in other carriages, to prevent overturning.

A machine of this sort was constructed in the last century by Stephinus, at Scheveling in Holland, and is celebrated by many writers. Its velocity with a strong wind is said to be so great, that it would carry eight or ten persons from Scheveling to Putten, which are forty-two English miles distant, in two hours.

Carriages

Fig. 1. p. 199.

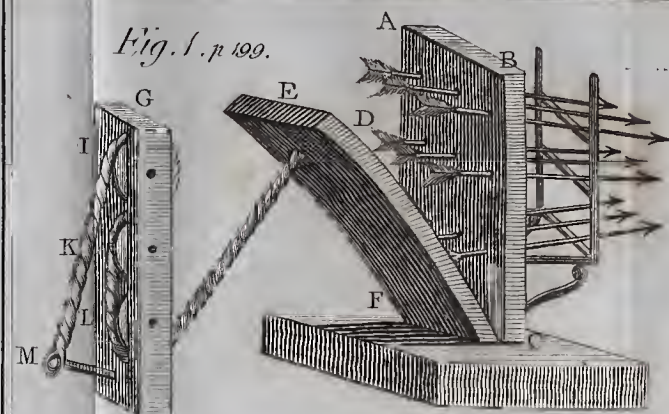


Fig. 2. p. 200.





Carriages of this kind are said to be frequent in China; and in any wide, level country, must be sometimes both peasant and profitable. The great inconvenience attending this machine is, that it can only go in the direction the wind blows: and even not then unless it blows strong; so that, after you have got some way on your journey, if the wind should fail, or change you must either proceed on foot, or go back. Some remedy for this inconvenience will be found in the next recreation. The Hollanders have, or had, small vessels, something of this kind, that carry one or two persons on the ice, having a sledge at bottom instead of wheels; and being made in the form of a boat, if the ice break the passengers are secured from drowning.

R E C R E A T I O N LXI.

To sail by land against the wind.

LET ABCD (Plate X. Fig. 1.) be the body of a sailing chariot: M the mast, to which are fixed the wings or sails EFGH; the two first of which EF, are here supposed to be expanded by the wind. R is the rudder by which it is guided. Therefore the wind driving the sails round, with the mast M, and the cog wheel K, take the teeth, placed perpendicular to the sides of the two fore wheels of the carriage, and consequently keep it in continual motion.

The body of this machine should not be large, nor placed very high, not only to prevent overturning, but that its motion may not be thereby impeded; for the velocity will be in proportion to the force of the wind on the sails to that on the body of the machine. Therefore if they
be

be both equal it will stand still ; or if the force on the body be the greatest, it will go backwards ; unless there be a contrivance to lock the wheels. The upper part of the machine next A, may be made to take off, when the wind is contrary, and there may be another set of sails placed between the two hind wheels, which will considerably increase its velocity. But after all, for general use, a common carriage must be preferable ; for this cannot be expected to go up a moderate ascent without great difficulty, nor down a declivity, when there is a strong wind, without danger ; and even on level ground, if the road be in any degree rough, its progress must be very slow, attended both with difficulty and danger. In an open country, however, where there is a large tract of level and smooth ground, and frequent strong winds, a machine of this sort will certainly be very convenient ; and in most countries, when made of a small size, may be useful to young people, by affording them a pleasant and healthful exercise.

R E C R E A T I O N LXII.

The uninvertible carriage.

THE body of this carriage must consist of a regular hollow globe, as A B (Plate X. Fig. 2.) at the bottom of which is to be an immoveable weight, and which must be proportioned to the number of persons, or the load the machine is intended to carry. Round the globe must go two horizontal iron circles D, E, and two others F, G, that are perpendicular to the former. All these circles must be made exactly to fit the globe, that it may move freely in every direction. The two horizontal circles are to be joined on each side by a perpendicular bar, one of which is expressed in the figure by H I. All these irons should be lined with leather, to prevent unnecessary friction. The body of the carriage may be either of leather or hard wood, but the latter will be most eligible, as least liable to wear. The wheel
on

on each side is to be fastened to the perpendicular bar by means of a handle K, that keeps it steady.

Now the body of this machine moving freely in the iron circles, every way, the center of gravity will always lie at C; therefore in whatever position the wheels are, or even if they overturn, the body of the carriage will constantly remain in the same perpendicular direction.

At L is placed a pin, round which is a hollow moveable cylinder: this pin moves up and down in the groove M N, that it may not impede the perpendicular motion of the circles, at the same time that it prevents the body of the machine from turning round in a horizontal direction. O, is one of the windows, P the door, and Q R the shafts to this machine.

When a carriage of this sort is intended for a single person, or a light weight,
it

it may be hung on swivels, in the same manner as the rolling lamp or the sea compass, which will make its horizontal motion still more regular : and when it is designed to carry several persons, by adding another perpendicular bar, on each side, between the two horizontal circles, it may be placed on four wheels. The body of this machine should be frequently oiled or greased, not only to prevent any disagreeable noise that may arise from its rubbing against the circles, but to prevent unnecessary wear in the several parts.

This carriage is not intended for smooth roads, or a regular pavement ; there, certainly, those of the common construction are much preferable ; nor should a carriage totally free from irregular motion be sought after by those who are in perfect health : but there are many persons, subject to different disorders, who, by being obliged to travel over rough roads in the common carriages, suffer tortures of which
the

Fig. 1. p. 202.

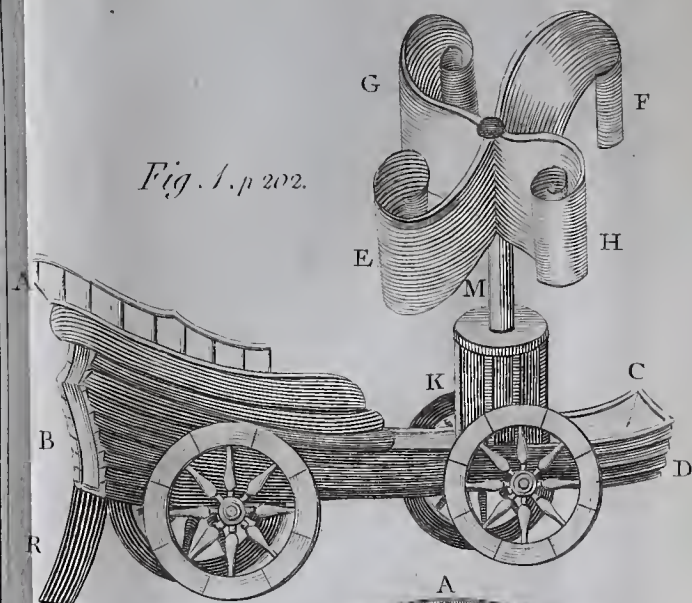
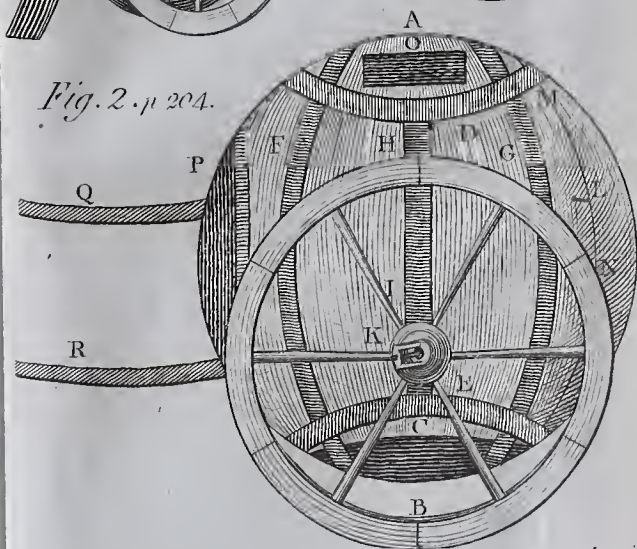


Fig. 2. p. 204.





the healthful have no idea, to all these, therefore, and to every one who is forced to travel through dangerous roads, a carriage of this sort must doubtless be highly desirable.

As this design may appear to some persons, on a superficial view, impracticable, we shall here insert an account of a similar carriage, which we have taken from the first volume of the *Abridgement of the Philosophical Transactions*, by Lowthorp, p. 592. There is not, however, any description of the manner in which that machine was constructed. The account is as follows: “ A new sort of calesh described
 “ by Sir R. B. This calesh goes on two
 “ wheels; carries one person: is light
 “ enough. Though it hangs not on braces
 “ yet it is easier than the common coach.
 “ A common coach will overturn if one
 “ wheel go on a superficies a foot and a
 “ half higher than the other, but this
 “ will admit of the difference of three
 “ foot

“ foot and one third in height of the fu-
“ perficies, without danger of overturn-
“ ing. We chose all the irregular banks,
“ and sides of ditches, to run over, and I
“ have this day seen it, at five several
“ times, turn over and over, and the horse
“ not at all disordered. If the horse
“ should be in the least unruly, with the
“ help of one pin, you disengage him
“ from the calesh without any incon-
“ venience (*a contrivance of this sort may*
“ *be easily added to the foregoing design.*)
“ I myself have been once overturned,
“ and knew it not till I lookt up, and
“ saw the wheel flat over my head: and
“ if a man went with his eyes shut, he
“ would imagine himself in the most
“ smooth way, though at the same time
“ there be three foot difference in the
“ height of the ground of each wheel.”

RECREATION. LXIII.

The columnar dial.

P
PLATE XI. Fig. 1. represents a column or obelisk *AB*, whose shaft *GH* is fluted, and divided by horizontal lines, that appear as joints, and serve to mark the hours: the inside of this column is hollow, and is represented by Fig. 2: in the base is placed the hollow cylinder *A*, constructed exactly in the same manner with that of the 53d Recreation of this volume, but here it is kept in motion by the weight *B*, fastened to a string that goes over the pulley *C*, and to this string is likewise fastened the index *H*, that, as the weight descends, points to the hours marked on the outside of the column, as is expressed in Fig. 1, at *H*. The axis of the cylinder comes through the front of the column, and to the end of it is fixed an index that points to the minutes of each hour, mark-

ed on a circle in the front of the base, as in Fig. 1. at B.

The striking part of this dial is contained in the capital of the column, (see Fig. 2.) where DE is an axis, on which are placed the two brass wheels F and G, that are of an equal diameter. On the circumference of the wheel G are six teeth, placed at equal distances from each other; these teeth are taken by the detent or lever IKL. The wheel F is likewise divided into six equal parts, in each of which is placed a different number of teeth from one to six. The short end of the detent or lever MNO takes the teeth of this wheel, and to the other end of it is fixed the hammer P, that strikes the bell Q.

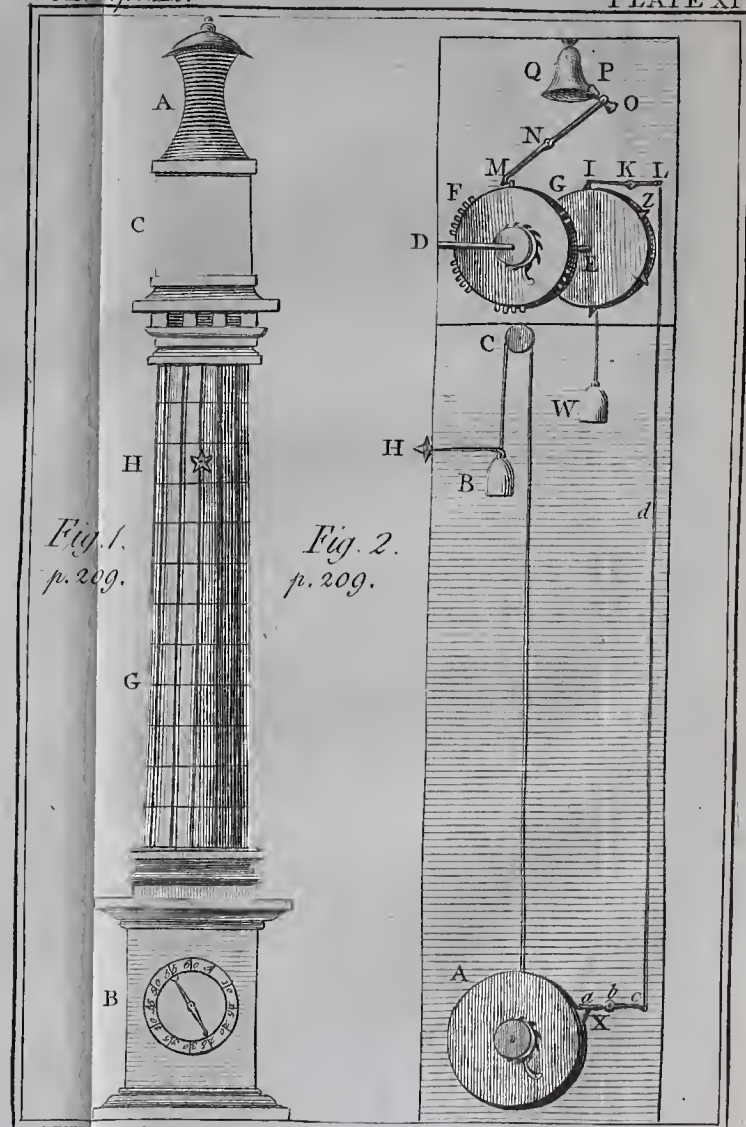
The wheel A making a complete revolution every hour, when it comes to X, its tooth raises the end *a* of the lever *a, b, c*, consequently depresses the opposite end *c*, which by means of the string *cd*, raises the

the

the end I of the lever IKL, and the wheel G is turned by the weight W from G to Z, but can go no farther; for the end I, of that lever, being heavier than the other end, descends again immediately after it has quitted the tooth. Now the wheel F being of the same dimension as G, and fixed on the same axis, must necessarily move the same space, in order to which it must push up the end of the lever MNO, that presses against one of its teeth, and that end descending again immediately, being heavier than the other, the hammer O will strike the bell; it will, in like manner, be forced over and fall between each tooth, till it come to the end of the division, and consequently give as many strokes on the bell as there are teeth in that division. As the end NO of the lever MNO is three times as long as MN, while the short end is pushed over one of the teeth, the other will be pushed three times as far from the bell.

Due care must be had in adjusting the weight to the effect it is to produce: for if it be too light, it will not overcome the friction of the lever with the teeth; and if it be too heavy, the wheel will move with too great velocity, and not give the lever sufficient time to fall in between the teeth. To the axis of each of the wheels A and F is fixed a ratchet-wheel and a ketch, by which they were wound up. The time of this dial's going may be considerably increased by adding one or more pulleys to those at C and W.

It is evident from the construction of this dial that it strikes from one to six only: it may, however, be made to strike all the twelve hours, but then the number of teeth on the wheel F must be increased from 21 to 78, and consequently the wheels must be larger or the teeth smaller, either of which would be inconvenient; and as we have observed elsewhere, simplicity is a capital excellence in
the



the construction of every machine. It would certainly be more eligible for clocks in general to sound no more hours than 6, as they would be less complex in their construction, the hours would be more readily told and less liable to be mistook ; nor could it be attended with any inconvenience, as it is impossible for any one, to whom time is of the least importance, not to distinguish morning, noon, and night from each other.

A clock of this sort may be constructed at a small expence and will make an elegant piece of furniture ; or if elegance be not regarded, the machinery may be placed in the corner of a room, with a plain board before, and it will answer the intention, equally well. It is easy to conceive, that with a small alteration this machine may serve as a reveilleur or alarum.

RECREATION LXIV.

An air chronometer.

PROVIDE a glafs tube (Plate XII. Fig. 1.) of about an inch diameter, and three or four feet long: the diameter of the infide of this tube muft be precifely equal in every part: at the bottom is to be a fmall hole, that is clofely covered with a valve. In the tube place a piston E, (Fig. 2.) which is made to fit it exactly, and muft be oiled, that it may move in the tube with the greateft freedom: in this piston there is a cock, that fhuts quite clofe, and from the top of it there goes a cord F, that paffes through the handle G.

Now the cock of the piston being clofed, it is to be let down to the bottom of the tube, and being then drawn up to the top, the air will rufh in by the valve
at

at the bottom of the tube, and support the piston. You are then to turn the cock, so as to make a very small vent, and the air passing slowly through that vent, the piston will gradually descend and show the hour, either by lines cut in the tube with a diamond, or marked with paint, or by small slips of paper pasted on the glass. If this chronometer should go too fast or slow, it may be easily regulated by altering the position of the cock in the piston, as it is on that the whole depends.

If, instead of marking the tube, you would have the time shown by a dial, it may be easily effected by placing an axis, to which the hand of the dial is fixed, directly over the tube, and winding the string, to which the piston is joined, round that axis: for then as the piston descends the axis will gradually turn the hand, and show the hour: but you are

to observe, that as the descent of the piston is not constantly regular, occasioned by the decrease of resistance from the quantity of subjacent air as the piston descends, the axis, therefore must not be a regular cylinder, but conical, like the fusee of a watch, as in Fig. 3. by which means the motion of the hand of the dial will be constantly uniform.

RECREATION LXV.

The lamp chronometer.

PLATE XII. Fig. 4. represents a chamber-lamp A, consisting of a cylindrical vessel about three inches high and one inch diameter, placed in the stand B. The inside of this vessel must be every where exactly of the same diameter. To the stand B is fixed the handle C, which supports the frame DEFG, about twelve inches high and four inches wide. This frame is to be covered with oiled paper, and divided into twelve equal parts, by horizontal lines; at the end of which are wrote the numbers for the hours, from 1 to 12, and between the horizontal lines are diagonals, that are divided into halves, quarters, &c. On the handle B, and close to the glass, is fixed the style or gnomon H.

Now

Now as the distance of the style from the flame of the lamp is only half an inch, if the distance of the frame from the style be six inches, then while the float that contains the light descends, by the decrease of the oil, one inch, the shadow of the style on the frame will ascend twelve inches, that is, its whole length, and show by its progression, the regular increase of the hours, with their several divisions.

It is quite necessary that the oil used in this lamp be always of the same sort, and quite pure, and that the wick also be constantly of the same size and substance, as it is on these circumstances and the uniform figure of the vessel, that the regular progress of the shadow depends.

To make this machine ornamental as well as useful, there may be drawn in the middle of the frame, yet so as to leave the divisions of the hours quite visible, the
figures

figures of trees, flowers, animals, or whatever else the owner's imagination shall suggest; and if they be properly painted, in lively colours, they will have a very pleasing effect.

RECREATION LXVI.

The nocturnal dial.

THE two wheels A and B (Plate XII. Fig. 5.) are of the same diameter, and have each fifty-four teeth: their axis are parallel, but have no connection with each other. The pinion C and the wheel D have each six teeth, and the wheel E eighteen teeth; the two last wheels, D and E, are placed on the same axis: all these wheels must be of brass or copper, and as light as possible. Near the circumference of the wheel A are the figures for the hours and their divisions, which are cut through the plate, and covered with oiled paper.

paper. On the wheel B, at F, is fixed a lamp, the oil of which must be of the purest sort, and the wick constantly of the same size and matter; and round the axis of this wheel is wound a rope, to which hangs the weight G.

Now the quantity of oil in the lamp is so adjusted, as to exactly counterbalance the weight G; but as the oil is continually decreasing, the weight must descend, though very gradually, and consequently turn the wheel B, and that must turn the pinion C and wheel D, which being fixed on the same axis as E, turns that also, and consequently the wheel A. But as each of the great wheels A and B have fifty-four teeth, the pinion C and wheel D only six teeth, and the wheel E eighteen teeth, it necessarily follows, that while the wheel B moves from F to H, that is, one-third of its circumference, the wheel A must make a complete revolution; and as
some

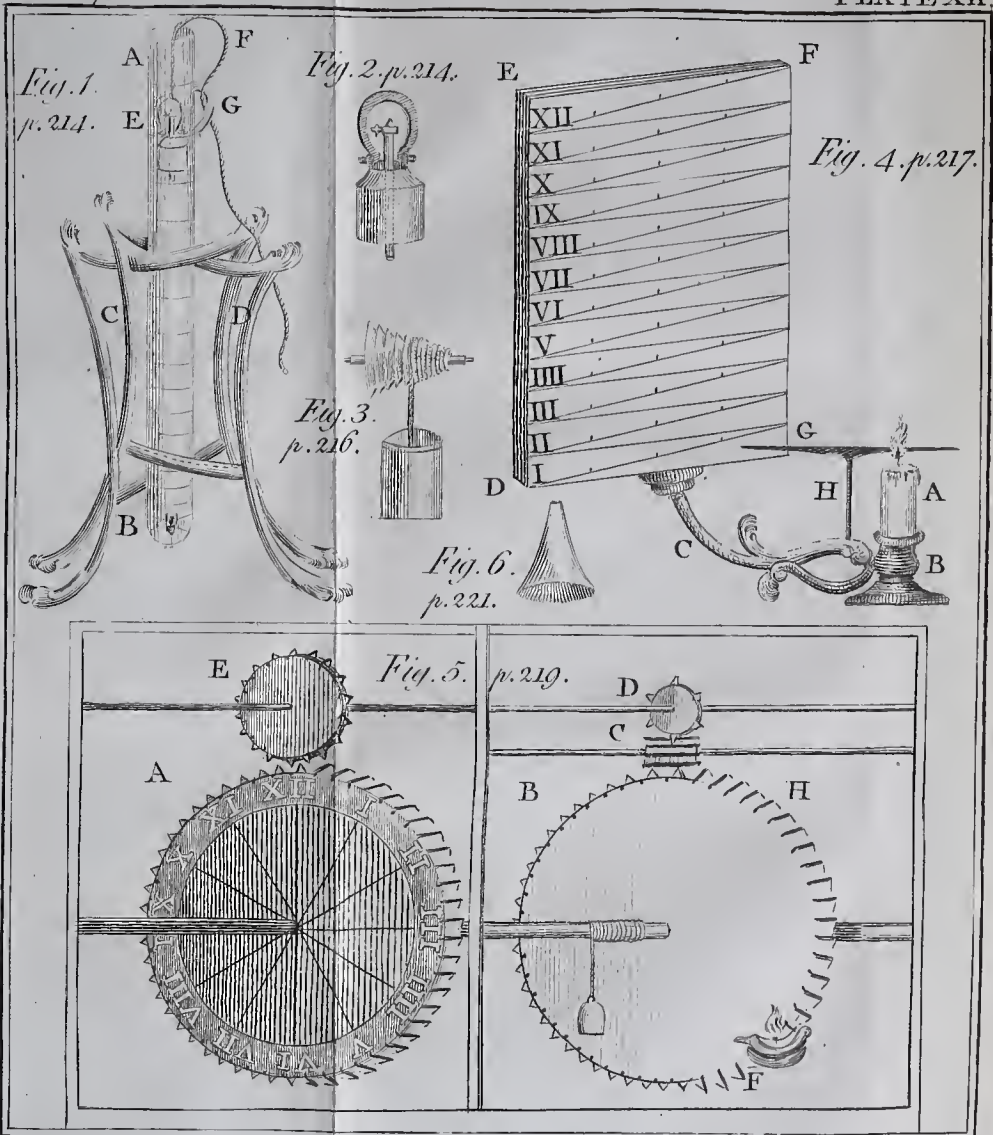
some parts of its circumference will be continually opposite the lamp, the number of the hour will be always visible.

A hollow cone or funnel, as Fig. 6, is to be placed to that side of the lamp opposite the wheel A, the small end of this cone should be square, and which will confine the light of the lamp to a determinate part of the wheel A: if a moveable lens be adjusted to this small end, the quantity of light may be extended or contracted at pleasure.

This dial may be made to sound the hours, by adding the apparatus described in the 63d Recreation, and fixing a tooth on the rim of the wheel A, against each hour, which will take the end of the lower lever, in the striking part of that machine, and it may like that serve as an alarum.

To

To those who are troubled with an infomny, or inability to sleep, whether from constitution or disease, a dial of this sort will prove an agreeable companion, as it will continually shew how the tiresome hours wear away; and to make it more amusing, over each hour some motto may be cut out; for if the diameter of the wheel be one foot, its circumference will be something more than three feet, and consequently there will be a space of three inches to every hour. In the twelve compartments under the hours there may be likewise figures of history, either religious or profane; or emblems of devotion, love, morality, or whatever else the temper and disposition of the owner may require; and if these figures be covered with transparent paper, properly coloured, this machine, at the same time that it answers the common purposes of a dial and lamp, will afford a pleasing representation; and as the wheels are in continual motion, and
the



the light confined to a certain space, one that is continually varying.

We might here give a much greater variety of mechanical constructions, but we choose to confine ourselves to such as are most remarkable, and which, when duly considered, will be quite sufficient to exemplify the foregoing aphorisms. They who are desirous of more variety, will readily find a great number of experiments that are constantly repeated by every writer on mechanics.

ADVERTISEMENT.
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DEFINITIONS.	p. 1
APHORISMS.	4

Of the amount and product of even and uneven numbers, aph. 1 to 6.—Of the divisibility of numbers, aph. 6 and 7.—Properties of the number 9, aph. 8 and 9.—Properties of arithmetic progressions, aph 10 to 14.—of geometric pro-

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greffions, aph. 14 and 15.—Of combinations and permutations, aph. 16 and 17.

THE ROMAN ABACUS. p. 11

An instrument by which any sum may be set down, added to or subtracted from, another, by counters, and without the use of figures.

NEPER'S RODS. p. 13

A method of multiplying and dividing by a table of figures, engraved on moveable rods (see Plate I. Fig. 1 and 2.)

THE CHINESE SWAN-PAN. p. 17.

An instrument that performs all the operations of arithmetic, by moveable balls strung on wires (Plate I. Fig. 3.) and without the aid of figures. A blind person, with this instrument may make any calculation with certainty.

R E C R E A T I O N I. p. 22

Any number being named by adding a figure to it, to make it divisible by nine.

By adding as much to the amount of the figures that compose the number, as will make it divisible by nine.

R E C R E A T I O N II. p. 23

A person having an even number of counters in one hand and an odd number in the other, to tell in which hand the odd or even number is.

By directing him to multiply the number in one hand by an odd number, and that in the other by an even number, and to tell you whether the amount of the two products be even or odd.

R E C R E A T I O N III. p. 24

A person making choice of several numbers, another is to name him the number by which the sum of those numbers is divisible.

By putting a parcel of tickets, marked with numbers divisible by 3, into one division of a bag, and into another division tickets marked with the number 3 only, and letting two persons draw one from each division.

R E C R E A T I O N IV. p. 25

To find the difference between two numbers, the greatest of which is unknown.

By subtracting the least number from an equal number of nines, and directing another person to add to, and subtract from, the amount, in a determinate manner.

R E C R E-

R E C R E A T I O N V. p. 27

To tell by the dial of a watch, at what hour any person intends to rise.

You tell him to place the hand of the dial at what hour he please, and you privately add 12 to that number ; you then tell him to count so many hours on the dial as are equal to the amount, and the last will be the hour required.

R E C R E A T I O N VI. p. 28

A person choosinꝑ any two out of several given numbers, and after adding them together, striking out one of the figures of the amount, to tell what the figure was.

By offering such numbers only as are divisible by 9, and the sum of any two of them is either 9 or 18, and contains no cypher.

R E C R E A T I O N VII. p. 29

Two persons choosing two numbers, and multiplying them together, by knowing the last figure of the product to tell the other figures.

By putting into one division of a bag tickets marked 73, and into another division such numbers, as when multiplied by 73, will end with the nine digits.

R E C R E A T I O N VIII. p. 31

The magical century.

If two persons stake a number of counters alternately, but never more than ten at once, he that stakes first must make the century, provided he make the others stake each time, equal to one more than the sum of one of the nine digits multiplied by 11—the same Recreation with a pack of cards, p. 32.

R E-

RECREATION IX. p. 34

The confederate counters.

A ring, a seal, and a snuff-box being chose by three persons, to tell, by means of twenty-four counters, and a verse of fourteen syllables, which of them each person has chose.

RECREATION X. p. 36

A person privately fixing on any number, to tell him that number.

By directing him to double, add to, and multiply that number, and subtract another number from it, in a determinate order.

R E C R E A T I O N XI. p. 37

Three dice being thrown on a table, to tell the number of each die, and the order in which they stand.

The person who threw the dice is to double and multiply each number, and subtract another number from the amount, as in the last Recreation.

R E C R E A T I O N XII p. 39

To tell the number a person has fixed on, without asking him any question.

By directing him to halve and triple his number four times, and by observing when he is obliged to add one to the sum, before he can halve it, and applying those cases to the syllables of eight Latin words.

R E C R E A T I O N XIII. p. 42

Thirty soldiers having deserted, fifteen of them are to be punished; so to place the whole

whole number in a ring, that you may save any fifteen you please, and it shall seem the effect of chance.

By placing them according to numbers annexed to the vowels of a Latin verse.

R E C R E A T I O N XIV. p. 43

Some person in company putting a ring, privately, on one of his fingers, to name the person, the hand, the finger, and the joint, on which it is placed.

Another person is to double, add to, and multiply the number of the rank in which the first person stands, and tell you the amount, from which you deduct a certain sum, and the remainder will answer the question.

O F A R I T H M E T I C A L M A G I C S Q U A R E S. p. 46

They consist of numbers in arithmetic progression, placed in equal rows, and
in

in such manner that the sum of each row taken either perpendicularly, horizontally, or diagonally, is the same—method of constructing these squares.

R E C R E A T I O N XV. p. 49

The series of numbers from 1 to 25, being wrote on that number of cards, after they have been shuffled, to deal them to five persons, either by twos or threes, at the option of the parties, and the amount of the numbers on each one's cards to be the same.

There is to be a wide card—table for disposing the cards, before they are shuffled, according to the magic square, p. 50—manner of dealing them, p. 51.

R E C R E A T I O N XVI. p. 52

To deal the thirty-two cards of the game of piquet to four persons, after you have shuffled them, and the parties have chose whether

C O N T E N T S. 235

whether you shall deal them by twos or threes, in such manner that all the cards in each person's hand shall be of the same suit.

Order of disposing the cards—manner of dealing them, p. 53.

OF GEOMETRIC MAGIC SQUARES. p. 54,

To be filled after the same manner as the arithmetic squares—the product of each line, taken in any direction, is the same.

R E C R E A T I O N XVII. p. 55

Several numbers being wrote upon cards, to shuffle them, and deal the whole, or part of them, to three persons, in such manner, that each one multiplying the numbers on his cards together, the product of each person's cards shall be the same; and to repeat the recreation after having shuffled the cards a second time.

The numbers wrote on the cards are to be those of the geometric magic square—
there

there must be three wide cards, p. 56—
method of repeating the experiment,
p. 57—may be performed with the
numbers of the arithmetic magic square.

RECREATION XVIII. p. 58

*To find the number of changes that may be
rung on twelve bells.*

By multiplying the numbers from 1 to
12 into each other.

RECREATION XIX. p. 59

*Supposing the letters of the alphabet to be
wrote so small that no one of them shall
take up more space than the hundredth part
of an inch; to find how many square
yards it would require to write all the per-
mutations of the twenty-four letters in
that size.*

The permutations of the twenty-four let-
ters are found as in the last Recre-
ation—the number of square yards re-
quired

quired to contain those permutations is 18620 times as large as the surface of the earth, p. 60.

R E C R E A T I O N XX. p. 60

To find how many different ways the eldest hand at piquet may take in his five cards.

This number found by the sixteenth aphorism—it is 15503 to 1 that he does not take in any five certain cards, p. 61

R E C R E A T I O N XXI. p. 61

To find the number of deals a person may play at the game of whist, without ever holding the same cards twice.

This number also is found by the sixteenth aphorism.

THE ARITHMETIC TRIANGLE, p. 62

Its construction—its use in finding the combination of small numbers, p. 63.

R E C R E-

R E C R E A T I O N XXII. p. 64

To find how many different sounds may be produced by striking on a harpsichord two or more of the seven natural notes at the same time.

This number, which is 120, found by the foregoing table.

R E C R E A T I O N XXIII. p. 64

Take four pieces of pasteboard, of the same dimension, and divide them diagonally, as in the figures, into eight triangles: paint seven of these triangles with the primitive colours, red, orange, yellow, green, blue, indigo, and violet, and let the eighth be white. To find how many chequers or four-sided figures, differing either in form or colour, may be made out of those eight triangles.

This number, which is 196, found in the same manner as in the last recreation, p. 66

R E C R E -

R E C R E A T I O N XXIV. p. 66

A man has 12 different sorts of flowers, and a large number of each sort. He is desirous of setting them in beds or flourishes, in his parterre. Six flowers in some, 7 in others, and 8 in others; so as to have the greatest variety possible; the flowers in no two beds to be the same. To find how many beds he must have.

This number which is 2211, is also found by the foregoing table.

R E C R E A T I O N XXV. p. 67

To find the number of chances that may be thrown by two dice.

This number is 36—the whole number of points is 252—it is an equal chance, at every throw, to bring seven points, p. 68—method of finding the number of chances on any number of dice.

R E C R E-

R E C R E A T I O N XXVI. p. 69

To discover the number of points on 3 cards, placed under three different heaps of cards.

As many cards are to be put over each of them as with the number of its points will make 15, then telling the number of the remaining cards, privately, and adding 16 to that number, the amount will be the number of points on the three cards.

R E C R E A T I O N XXVII. p. 70

The ten duplicates.

Twenty cards being laid in pairs, and in four rows, several persons are to look at different pairs, and tell you in which rows they are, when you tell them, by the aid of four Latin words, which cards they looked at.

R E C R E-

R E C R E A T I O N XXVIII. p. 72

*To name the number of cards that a person
shal! take out of the pack.*

This is done by previously disposing the
cards in a certain order, and by an
English verse to aid the memory.

R E C R E A T I O N XXIX. p. 74

*A century of different names being wrote on
the cards, to tell the particular name that
any person has thought on.*

A hundred names are wrote on 10 cards,
and the last name of each card begins
with one of the letters of a word that
has ten letters ; and on ten other cards,
the same hundred names are wrote, in
different dispositions. A person is to
draw a card from the first ten, and
after fixing on a name, give it you
VOL. I. R again

again you then show him the other ten cards, and when he tells you the card that has the name, you tell him, by means of the last name on the card he drew, which it is. This recreation may be performed with twenty cards, instead of ten; and questions and answers may be used instead of names. 78

OF THE COMBINATIONS OF THE CARDS. p. 78.

The tables formed by these combinations are applicable to many other subjects beside cards—manner of shuffling the cards, so as to make them correspond to the tables, p. 79.

Table of combinations for ten numbers, and for one, two, and three shuffles, p. 82

Table for twenty-four numbers 83

Table for twenty-seven numbers 84

Table for thirty-two numbers 85

R E C R E A T I O N XXX. p. 86

Several letters that contain no meaning, being wrote upon cards, to make them, after they have been twice shuffled, give an answer to a question that shall be proposed; as for example, What is love?

The twenty-four letters of the answer are to be wrote on that number of cards, and the answer itself to be wrote on a paper; the numbers from 1 to 24 are to be affixed to the letters, and the cards to be disposed according to the third column in the table for twenty-four numbers—necessary observations for conducting this and similar experiments, p. 88.

R E C R E A T I O N XXXI. p. 90

The twenty-four letters of the alphabet being wrote on so many cards, to shuffle them and pronounce the letters shall then be in their natural order, but that not succeed-

R 2

ing

ing to shuffle them a second time, and then show them in proper order.

The cards are here to be disposed after the same method as in the last recreation—the experiment is to fail at first, that it may appear the more extraordinary after the second shuffle.

R E C R E A T I O N XXXII. p. 91

Several letters being wrote promiscuously upon 32 cards, after they have been once shuffled, to find on a part of them a question; and then shuffling the remainder a second time, to shew the answer.

The letters of the question and answer, which are 32, are to be wrote on the cards; the letters of the answer, which are ten, are to be wrote on a paper, and the numbers from 1 to 10 affixed to them. They are then to be ranged by the second column of the table for ten numbers, and the whole thirty-two cards are

are next to be disposed by the second column of the table for that number—there is to be a long card, by which they are to be cut and then shuffled,
p. 93

R E C R E A T I O N XXXIII. p. 94

To write 32 letters on so many cards, then shuffle and deal them by twos to two persons in such manner, that the cards of one shall contain a question, and those of the other, the answer.

The numbers from 1 to 32 are to be wrote over the letters of the question and answer ; they are then to be ranged according to the first column of the table for thirty-two numbers, shuffled and dealt.

R E C R E A T I O N XXXIV. p. 96

The five beatitudes.

These five blessings, which are science, courage, health, riches, virtue, are to

R 3 be

be found on thirty-two cards that are dealt to five persons—the numbers from 1 to 32 are to be wrote over the letters of those words in a determinate order : the cards are then to be ranged according to the first column for thirty-two numbers. The five beatitudes being wrote, each of them on four cards, each person is to draw one from one of the fours, and when the other cards are dealt, one by one, each person will have the same word on the cards dealt him as on that he drew.

RECREATION XXXV. p. 98

The cards of the game of piquet being mixed together, after shuffling them, to bring, by cutting them, all the cards of each suit together.

The order in which the cards are to be ranged before the first shuffle, p. 99—they are then to be cut at a wide card, and the part cut off laid aside ; the remaining
cards

cards are to be shuffled a second time, and cut at another wide card ; the same operation is to be repeated a third time ; and the four suits will then be all separate.

R E C R E A T I O N XXXVI. p. 100

The cards at piquet being all mixed together, to divide the pack into two unequal parts, and name the number of points contained in each part.

The cards are to be disposed by the table for thirty-two numbers ; they are then to be shuffled, according to order and cut at a wide card, when each parcel will have a determinate number.

R E C R E A T I O N XXXVII. p. 103

The inconceivable repique.

This recreation is to be performed with the cards ranged in the order described

R 4 in

in the last : they are to be shuffled a second time, and cut at the wide card, and they will be then ranged in such order, that you will repique your adversary, though you let him choose, after the cards are cut, in what suit you shall make the repique—in a particular circumstance you must pass the three bottom cards to the top, p. 108.

RECREATION XXXVIII. p. 109

The metamorphosed Cards.

Thirty-two different words being promiscuously wrote, and four different colours and objects painted on thirty-two cards, they are to be shuffled as before, and dealt to four persons, and after the first deal every one's cards are to be all of the same colour : after the second deal they are all to have the same object ; and after the the third deal each person's cards are to contain a different sentiment.

R E C R E A T I O N XXXIX. p. 113

The repique with carte blanche.

The order in which the cards are to be disposed before the deal, p. 114—the hands of the two players, p. 115—one of them is to have the choice of the two hands, on condition of his being eldest or youngest, p. 116—method of the other's discarding accordingly.

R E C R E A T I O N XL. p. 117

Case at piquet, where you repique the elder hand, though he have the choice of the cards after they are dealt.

The order in which the cards must stand after they have been cut—the hands of the two players, p. 119—one of the players is then to choose either hand, but without seeing them—manner in which the other must discard, p. 120.

R E C R E -

R E C R E A T I O N XLI. p. 121

Case at piquet, where you give the other player not only the choice of the suite in which he will be repiqued, but that of dealing the cards by twos or threes, and of taking either hand after they are dealt, you being to tell and play first.

Previous disposition of the cards ; there are to be four wide cards—if they are cut at any one of the wide cards, the stock will be all of one suit, p. 122—the hands and rentrées of the two players, when the cards are dealt by twos and when they are dealt by threes, p. 123—method of discarding according to the hand the adversary chooses, and as the deal is by twos or threes, p. 124

R E C R E A T I O N XLII. p. 126

An exemplary case at piquet, where you repique your adversary, after giving him the

the coice of having the cards dealt either by twos or threes.

Table for disposing the cards in this and like cafes, p. 127—remark on the foregoing manoeuvres at piquet, p. 131.

R E C R E A T I O N XLIII. p. 132

Several different cards being shown to different persons, that each of them may fix on one of those cards, to name that on which each person has fixed.

As many cards are to be shown each person as there are persons to choose; each one's cards to be laid down separately, and the first person's card will be the first in the heap where it is; the second person's card the second, &c.—The same recreation may be performed with a single person, p. 133.

R E C R E A T I O N XLIV. p. 134

To name the rank of a card a person has drawn from a piquet pack.

By assigning a certain number to each card, and adding the number of the first to that of the second, &c. rejecting the tens and carrying the remainder, and subtracting 4 from 10 or 20, for the number of the card drawn.

R E C R E A T I O N XLV. p. 135

To tell the amount of the numbers of two cards that a person has drawn from a common pack of cards.

He is to add as many cards to each of those he has drawn as will make its number 25. You then tell the remaining cards, silently and their number will be the amount of the cards drawn. This recreation may be performed without telling
ing

ing the cards, p. 136—or with a pack of piquet cards, p. 138.

RECREATION XLVI. p. 139

To tell the amount of the numbers of any three cards that a person has drawn from the pack.

You are to draw a single card yourself, to make the remaining number divisible by three: the person is then to add as many more to each of his cards as will make its number 16, and the number of the remaining cards will be the amount of the cards he drew. This recreation also may be performed without telling the remaining cards, p. 140, —and with a pack of piquet cards, p. 141.

D I F F E R E N T M E T H O D S O F
W R I T I N G I N C Y P H E R.

R E C R E A T I O N XLVII. p. 143

To communicate intelligence by a pack of piquet cards.

The parties are previously to agree how the cards are to be disposed and shuffled—he who sends the cypher copies the letters on thirty-two cards, alternately, and shuffles them as agreed, p. 144—example of a cypher of this kind—methods of making it more difficult to decypher, and less liable to suspicion, p. 146.

R E C R E A T I O N XLVIII. p. 147

The mystical dial.

A moveable circle of pasteboard is placed within another circle, and on each of them are wrote the letters of the alphabet

bet (Plate II.) The moveable circle is placed as agreed on between the parties and the letters of the one wrote for the other—the same intention may be answered by a ruler, p. 148.

RECREATION XLIX. p. 149

The corresponding spaces.

Similar spaces to be cut in two pieces of pasteboard, and one of them kept by each party. The secret intelligence to be wrote in these spaces, when laid on a paper, and the distances between them to be filled up by words that make a different sense.

RECREATION L. p. 151

The musical cypher.

The construction of this instrument is similar to that of the 48th Recreation. The notes of musice answer to the letters of the alphabet (Pl. III.) The cypher ,

- pher to be wrote on ruled paper, as a piece of music, p. 152—is liable to very little suspicion, p. 153.

Rules for decyphering p. 153

Example of a cypher wrote in arbitrary characters, and the words separate from each other 156

A cypher wrote in arbitrary characters, and the words all close together 157

Manner of decyphering a writing of this sort 158

Method of rendering a similar writing extremely difficult to decypher 158 (note)

The contents of the two foregoing cyphers 159

R E C R E A T I O N LI. p. 160

Visual Correspondence.

The letters of the alphabet are cut thro' a circle of wood, near its circumference, and the circle being made to turn on a pole, the letter wanted is brought before

fore an opening at the top of it, and a light placed behind the letter (Plate IV. Fig. 1 and 2.)—method of using this machine, p. 161—a telescope is necessary when the distance is considerable, p. 162—particular purposes to which this machine may be applied, p. 163.

R E C R E A T I O N LII. p. 164.

Auricular Correspondence.

Two bells are placed at the top of a building, and the letters of the Alphabet are expressed by the number of strokes on one or both bells—a correspondence may be carried on by this contrivance, where that of the last recreation can have no effect.

M E C H A N I C S.

DEFINITIONS

p. 169

APHORISMS

172

Properties of moving bodies, aph. 1 to 12—Properties of pendulums, aph. 12. to 16.—Of the mechanic powers, aph. 16 to 26.—Of compound machines, aph. 26, to the end.

R E C R E A T I O N LIII. p. 180.

To construct a mechanical dial, without wheels, spring or weight.

This dial consists of a hollow cylinder, (Pl. VI. Fig. 1 and 2.) on the ends of whose axis are wound two strings, the other ends of which are fastened to the top of the wainscot. Within the cylinder are five partitions, and between them water is placed, which passing,
by

by a small hole, from one partition to the other, causes the cylinder to descend slowly and show the hour, by the ends of the axis pointing to a table of numbers on the wainscot.

R E C R E A T I O N LIV. p. 183.

A dial to shew the hour by gradually descending an inclined plane.

It consists of two parallel plates connected by a hoop (Plate VI. Fig. 3 and 4.) Between the plates are a train of wheels, and on the outside is a weight, which is fastened to the centre wheel, and therefore causes the dial to descend in a regular progression—this dial will go for any time, according to the length of the inclined plane, p. 186.

R E C R E A T I O N LV. p. 187.

*A clock to go perpetually by the influence of
the celestial bodies.*

This clock is of the common construction, but is placed against a wall by which the tide flows, and is moved by that, as that is by the moon, &c.

R E C R E A T I O N LVI. p. 190.

The inscrutable lock.

The inscrutability of this lock arises from the combinations of the moveable parts of the ward of the key, with the different positions in which the scutcheon before the lock may be placed, (Plate VII. Fig. 1 and 2.) which make it more than eleven thousand four hundred and ninety-six millions to one, at every trial, that a stranger does not
open

open the lock : which, however is opened instantly by the owner.

R E C R E A T I O N LVII. p. 193.

So to dispose a hand-mill, to grind corn, &c. that being once put in motion, it shall work incessantly without the assistance of any animal power.

This mill is to be moved by a smoke jack—a description of that machine (Plate VII. Fig. 3.)—as the motion of the jack is incessant while there is smoke in the chimney, the motion of the mill connected with it must be incessant also—this machine may be applied to other useful purposes.

RECREATION LVIII. p. 195.

A carriage to go without any force but what it receives from the passengers.

This carriage is moved by machinery (Plate VIII. Fig. 1 and 2.) contained in a box that is placed behind it, and is worked by the footman—might be moved, with equal or greater facility, by the person who sits in it, p. 197—the use or convenience of this carriage.

RECREATION LIX. p. 198.

The catapulta.

This machine (Plate IX. Fig 1.) used by the ancients to throw darts against their enemies—amazing force of some darts (note)—use to which this machine may be applied, p. 199.

RECRE-

R E C R E A T I O N LX. p. 200.

*To sail as fast, with a fair wind, by land
as by water.*

By a sailing chariot, or boat fixed on four wheels, (Plate IX. Fig. 2.)—its surprising velocity—similar machine to go on the ice, p. 201.

R E C R E A T I O N LXI. p. 202.

To sail by land against the wind.

The body of this machine is similar to that in the last recreation, (Plate X. Fig. 1.) but on the inside there are wheels that are worked by the mast, which is turned round by the force of the wind against its wings; and the wheels within the machine communicating with those on which it runs, drive it forward—the
advan-

advantages and inconveniencies attending this machine, p. 203.

R E C R E A T I O N LXII. p. 204.

The uninvertible carriage.

This carriage consists of a hollow globe, furrounded by two perpendicular and two horizontal brass or iron circles, in which it moves freely every way: its two wheels are fixed to two perpendicular pieces; and at the bottom of the globe is a weight that keeps it constantly upright—the great utility of this carriage in certain circumstances, p. 206—account of the trial of a similar machine, p. 207.

R E C R E -

R E C R E A T I O N LXIII. p. 209.

The columnar dial.

The case of this dial is a hollow column, in the base of which is the wheel that guides the hour and minute hands ; and in the capital is the machinery that strikes the hours. On the shaft of the column the hours are marked by horizontal lines, to which an index points as it descends from the top of the shaft to the bottom ; and on the base is a circle of minutes, marked by a hand fixed on the end of the wheel within.

R E C R E A T I O N LXIV. p. 214

An air chronometer.

This chronometer consists of a glass tube, wherein a piston is placed, that has a cock by which the subjacent air is suffered

ferred to pass very slowly : as this piston descends it shows the hours, by divisions marked on the tube—a dial may be added to this chronometer, the hand of which may be moved by the string that is joined to the piston.

R E C R E A T I O N LXV. p. 217.

The lamp chronometer.

The shadow of a style, placed before a lamp is thrown upon a frame covered with oiled paper, on which the hours and their divisions are marked. This instrument may be made ornamental as well as useful.

R E C R E A T I O N LXVI. p. 219.

The nocturnal dial.

This dial consists of two large and three small wheels, a weight, a lamp, and a hollow

hollow cone. Through one of the large wheels, which is placed in the front of the machine, the figures for the hours are cut, on each of which the light of the lamp is directed to fall, by the hollow cone, in a regular progression—this dial may be made to sound the hours, or serve as an alarm, p. 221.—method of making this machine exhibit a pleasing representation, p. 222.

